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THE WEEKLY OF ADVANCED TECHNOLOGY

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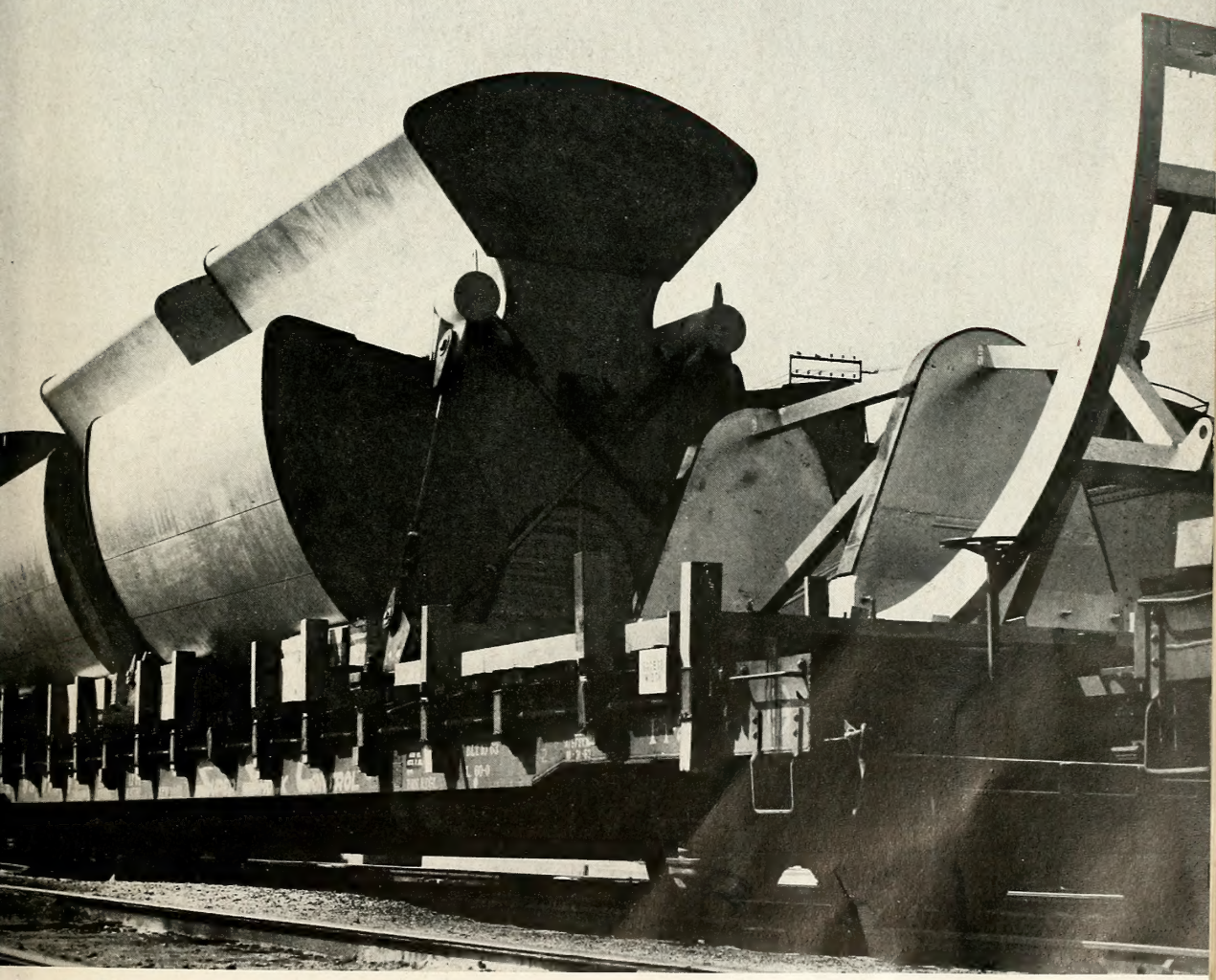

Aerojet Ships Core for 260-in. Solid Motor

Eurospace Seeks U.S. Cooperation . . .
JPL To Get Voyager Management Ta
Powerful Hybrid Booster Proposed . .

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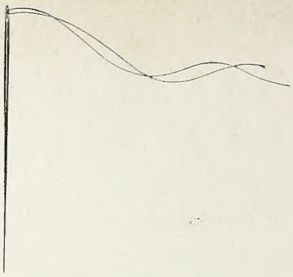
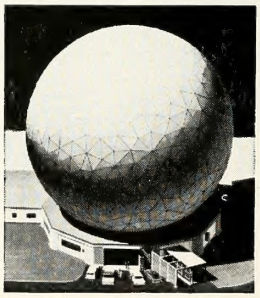


This needle is invisible to the human eye at 75 feet



But it can be found 500 miles out in space

The same sensitive system that can find and track needles 500 miles out in space can follow an astronaut, communicate with a space probe 100 million miles from the earth or detect energy from a galaxy 300 million light years away.

It is the 120-foot microwave antenna system on Haystack Hill at Tyngsboro, Massachusetts. Computer-operated, it is the most precise moveable instrument of its size ever built by man . . . and the most perfect large X-band antenna in the Free World.

It can resolve objects down to 1/60th of a degree. See a target with three orders of magnitude less cross-section at 2,000 miles. Operate with extraordinary precision at frequencies up to 10,000 megacycles per second — and perhaps far higher.

Though it is 40 yards in diameter and weighs 171 tons, the Haystack antenna is virtually a perfect parabola. Its maximum surface deviation is ±0.075 inch.

This milestone in man's quest for knowledge was built for the United States Air Force by North American Aviation/Columbus Division.

Through the diversification of its divisions, North American Aviation is also a leader in nuclear energy, electronics, rocketry, aviation, life sciences and space flight.

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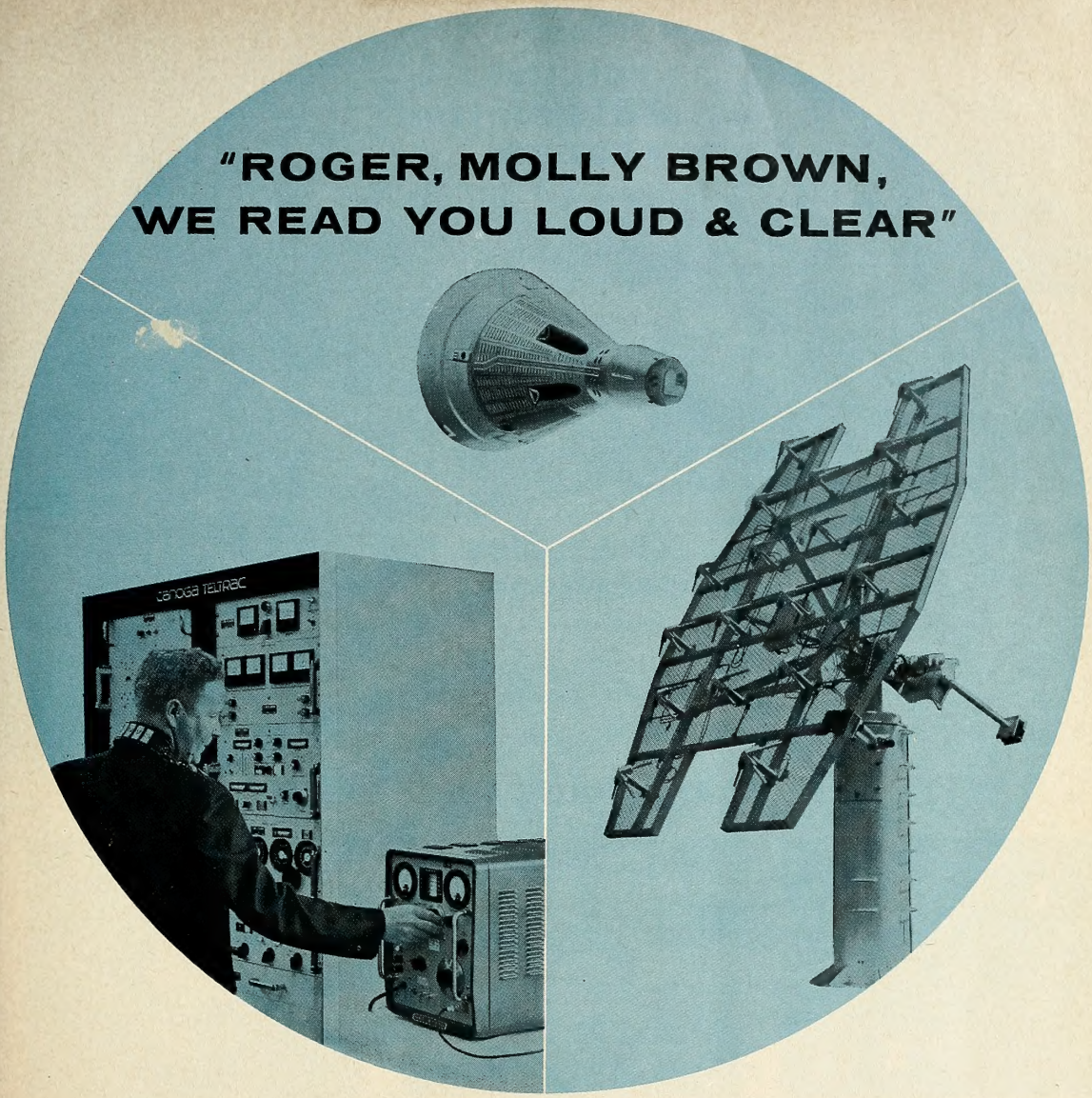

Our first "space twins" were supported by Canoga TELTRAC systems located throughout the NASA worldwide tracking network. During GT-3 Canoga operated a tracking station at its plant in Chatsworth, California. Telemetry and voice communication data were successfully received on all three orbits. *The technical staff at Canoga congratulates the GEMINI team for a job well done. We were proud to be a part of this effort.*

canoga

CANOGA ELECTRONICS CORPORATION 8966 Comanche Ave., Chatsworth, California 91311
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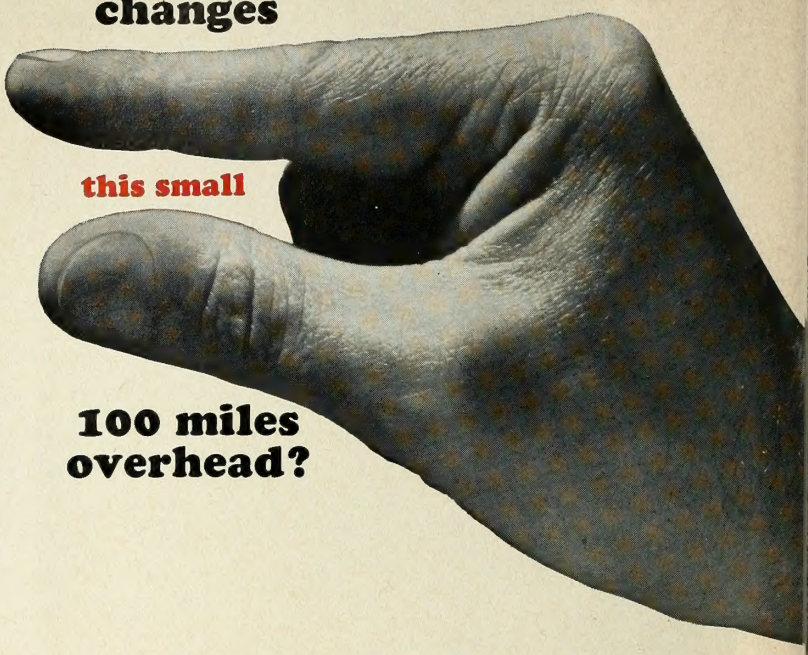
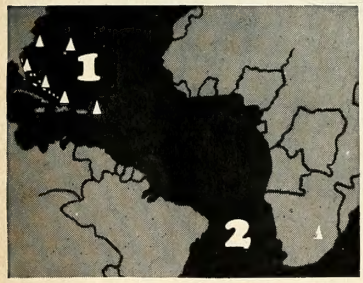
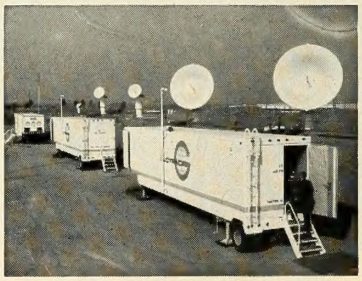
How do you detect satellite motion changes



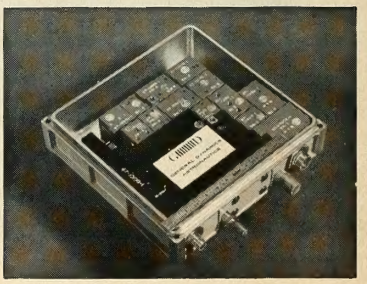
With a GD/E tracking system like this:



GLOTRAC* DEPLOYMENT: The uprange multilateration tracking stations (1) are at Cape Kennedy, Bermuda, Eleuthera, Antigua, Grand Turk, and North Carolina. The long baseline interferometer station (2) is at Pretoria, South Africa.



SYSTEMS CAPABILITIES: Key to GLOTRAC accuracy is sophisticated data processing which uses measured data for self-calibration and evaluation. All measuring equipment is self-contained in a van for land, sea, or air mobility.



MICRO-MINIATURIZATION RELIABILITY: Vehicle-borne link for the GLOTRAC system is a miniaturized (2.25" x 7.86" x 7.7") Type G Transponder, a solid-state, phase-locked transmitter/receiver packed in welded modules. It is the latest in a line of transponders which have a reliability of 99.8% in more than 500 flights.

One-inch satellite motion changes can now be detected by the U.S. Air Force's new GD/E GLOTRAC tracking network. It demonstrated its capabilities recently when Titan and Centaur missiles hurled satellites into orbit along the ETR. During power flight phases they were each tracked successfully by the uprange GLOTRAC multilateration tracking system. After they passed over the uprange radio horizon they were acquired by the Pretoria, South Africa, station which is a long baseline interferometer mobile unit. This demonstrated GLOTRAC's unprecedented —and uncanny—tracking accuracy over globally dispersed stations, and GD/E's excellence in systems capabilities and reliability in miniaturized packaging techniques. For further information, write Product Mgr., Tracking Systems Dept., General Dynamics/Electronics, P.O. Box 127, San Diego, Calif. 92112.

*Trademark—General Dynamics Corporation

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THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 18 May 3, 1965

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THE COVER

Aluminum core of NASA's 260-in.-dia. solid rocket motor being developed by Aerojet-General Corp. has arrived at the firm's Dade County, Fla., plant for mating with 60-ton rocket motor chamber. Propellant will be poured around core. NASA plans to fire two such Aerojet motors.

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Experimental Engineers . . .

Our Experimental Engineering Department has a variety of attractive openings for graduate engineers in the areas listed below. Since this work involves the development and refinement of highly-sophisticated (and frequently unorthodox) propulsion devices, these positions offer unusual challenge and opportunities for advancement.

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letters

Automation Run Wild?

To the Editor:

Congratulations on your superb editorial of April 12 ("Moon Struck"). The duplication of effort, unrealistic goals, inefficient management, criminal wastes of money, etc., is quite evident in our space program. How some of our most important and intelligent space scientists can stand by and downgrade the importance and absolute necessity of man in our space effort is quite beyond me. Tasks that man could perform much more effectively and precisely are often assigned to automated spacecraft and vehicles that can at best give us very vague information that could be much more satisfactorily acquired by man himself. Such waste! No wonder our space program is always behind schedule. If the unnecessary and unuseful parts of our program were eliminated, we could speed up our manned space effort immeasurably. I shall indeed be surprised if the United States succeeds in placing a man on the Moon by 1970 or a man on Mars by 1990! And still there are those who seriously believe that the U.S. will beat the "others" to the Moon.

Erich A. Aggen, Jr.
Executive Secretary
Theoretical Astro. Engineering Club
Liberty, Mo.

Speeding Up Gemini

To the Editor:

The recent flight of Maj. Grissom and Lt. Cmdr. Young was very spectacular, but too conservative. As is, according to present plans, the rest of the *Gemini* program. We still have time to accelerate our manned space effort much faster to cut down the Russian lead.

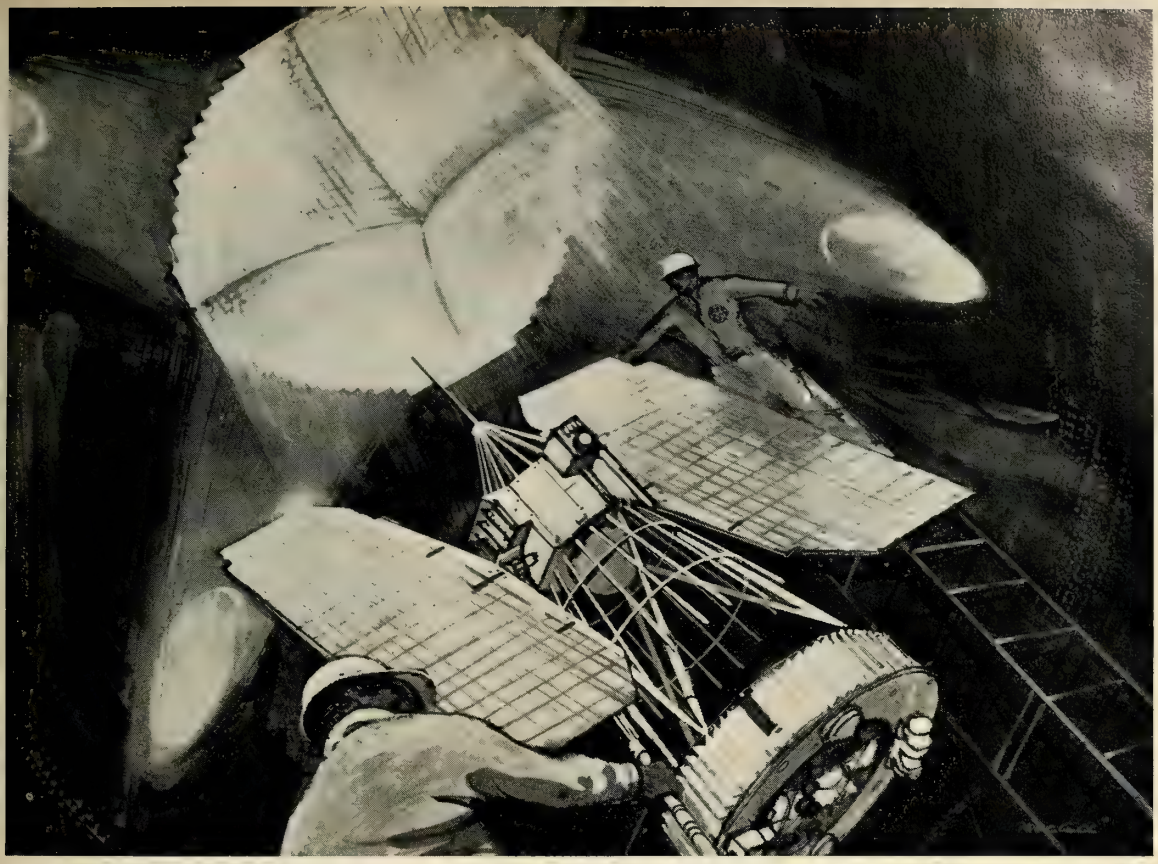
With *GT-4* one of our astronauts should leave the spacecraft completely. With *GT-4*, rather than *GT-6*, doing this in 1965 instead of in 1966. With *GT-5* we should attempt a rendezvous with the *Agena-D* target vehicle, instead of with *GT-6*. With *GT-6* we should do the same, but try to rendezvous with a second *Agena*.

With *GT-8* we should try to undertake a circumlunar mission, by using the *Saturn IB/Centaur*. With its ability to launch a 14,000-lb. payload to the Moon, it could easily launch a *Gemini* to the Moon and back. We could accomplish this in late 1966, cutting about one year off our timetable.

The rest of the *Gemini* program, presently unplanned, should be used to prepare for *Apollo*. Possibly, by accomplishing much of *Apollo's* job with *Gemini*, we could easily beat the 1970 lunar-landing deadline. Even, perhaps, do it in 1968.

Maybe we won't be able to move this fast. But we have to speed up our manned space program if we are to be the leaders to the Moon and beyond.

Gerald F. Butkus
Clifton, N. Y.



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Immediate openings now exist at Valley Forge and Philadelphia, Pa. in **systems analysis...systems simulation...guidance & control analysis...measurements & environments...materials development...structural mechanics...project engineering...guidance & control equipment design...command & telemetry design...radar discrimination...nuclear power (SNAP)...electro-chemistry...and nuclear effects.**

Interested applicants are invited to inquire further by writing to Mr. J. S. Barson, Dept. 94-A, Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia 1, Pa. An equal opportunity employer.

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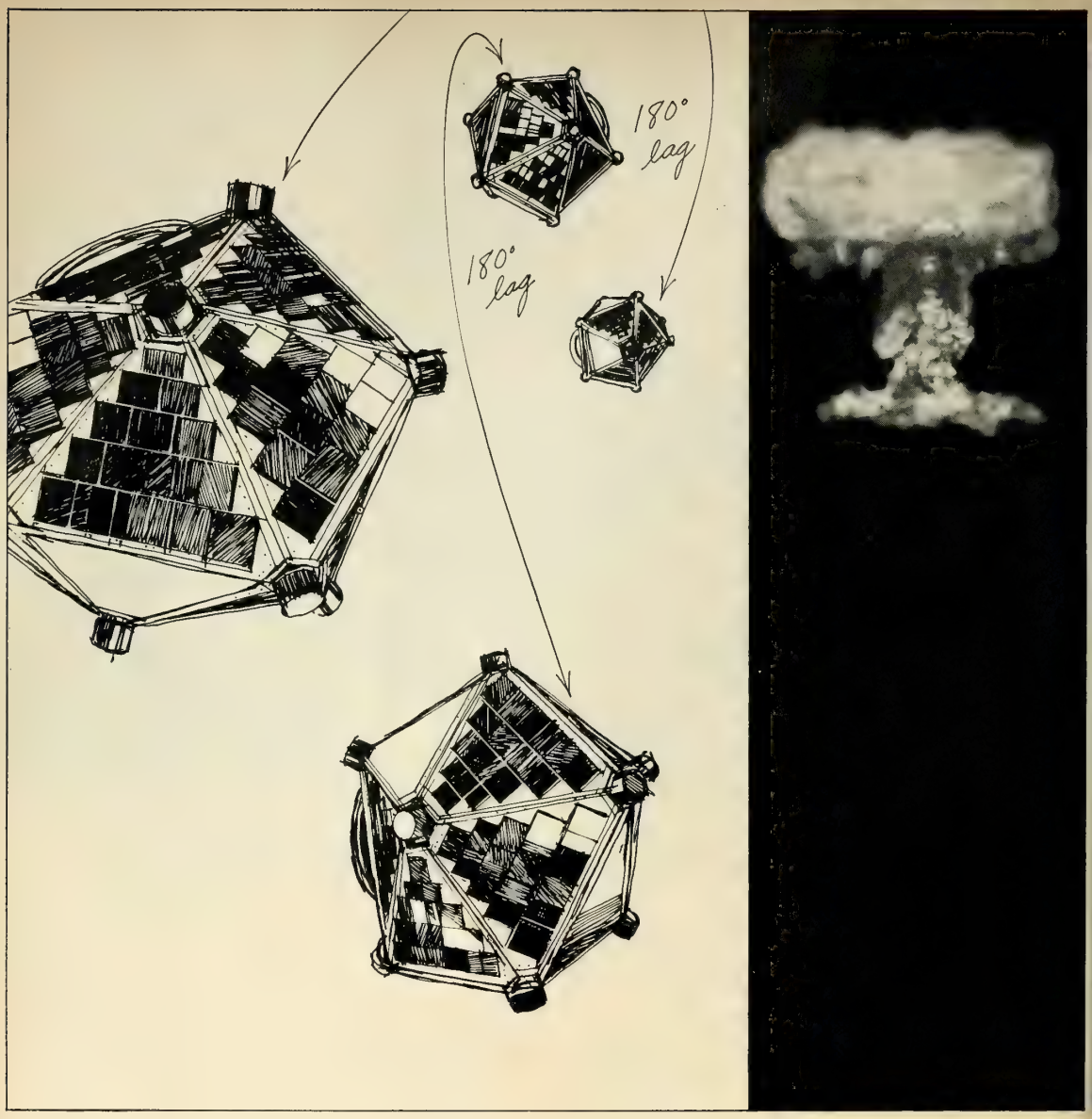

40,000 ORBITAL HOURS–AND STILL ON PATROL

These Vela nuclear detection satellites are the hardest workers in spacecraft history. Built by TRW, they are operating well beyond their expected lifetime to assure continuing protection from clandestine atomic blasts in space. Launched October, 1963, and July, 1964, this system has logged 1700 days, 2.5 billion miles and $30 million savings in launch and operations costs.

TRW, designer and builder of more kinds of spacecraft for more different space missions than any other manufacturer, is working on the nation's most advanced space projects. Current programs include communications satellites for Comsat, anti-submarine warfare, advanced space probes, Gemini and Apollo mission analysis, advanced Vela nuclear detection satellites, Pioneer interplanetary spacecraft, OGO satellites, Mars mission studies, advanced ballistic missile studies and the LEM descent engine. These and other advanced space activities create opportunities in: Theoretical Physics, Systems Engineering, Radar Systems, Experimental Physics, Applied Mathematics, Space Communications, Space Physics, Antennas and Microwaves, Inertial Guidance, Analog Computers, Solid State Physics, Computer Design, Telecommunications, Digital Computers, Guidance and Navigation, Electromechanical Devices, Engineering Mechanics, Applied Aerodynamics and Propulsion Systems. For information about TRW opportunities in Los Angeles, San Bernardino, Calif., Houston, Cape Kennedy, and Washington, D.C., write TRW Professional Placement, One Space Park, Dept. MR-5 Redondo Beach, Calif. TRW is an equal opportunity employer.

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668

The Countdown

WASHINGTON

Goddard Considers New Solar Satellite

Goddard Space Flight Center has asked industry for expressions of interest on development of a solar-monitoring satellite which would use already-developed hardware. Still unfunded, the project would call for either four flight models and one prototype at a cost of $2.8 million or one prototype and one flight model at a cost of $1.5 million. Firms wishing to obtain a description of the contemplated satellite, which will weigh about 400 lbs., should contact the center by May 7.

DOD-NASA Tracking Agreement Near

Watch for announcement by Dept. of Defense and NASA of a new agreement on management of tracking stations. It will provide that management and logistic support responsibility in most cases will be handled by the dominant user of the station. First stations to be affected are those on Ascension and Antigua Islands, to be managed by the Air Force. Canton Island station will be transferred from Air Force to NASA by July 1. These are the only current stations affected by the agreement, designed to cover future installations.

It's the Heat and the Humidity

Humidity in the *Apollo* Command Module still is an unresolved problem. *Apollo* program manager Joseph P. Shea believes the inability of the spacecraft cooling system to handle increased metabolic heat and perspiration produced by the crew working in a shirt-sleeve environment may restrict the crew to spacesuits for the entire lunar journey.

Report on 260-inch Rupture Due Soon

Report on the rupture of the Thiokol half-length 260-inch solid motor case during a structural test is expected on May 10. Investigating group set up by NASA shortly after the failure held its first formal meeting on April 26 but has not released any preliminary findings.

Nike-X Viewed as Anti-Sub Missile

Despite Air Force concern with updating components of the SAGE system to provide added warning of the launch or approach of sea-launched ballistic missiles, a top Defense official sees the threat as less of a problem if and when *Nike-X* is deployed. Asked before the House Armed Service Committee if *Nike-X* will be able to handle the submarine-launched missile, Deputy Secretary of Defense Cyrus Vance said yes.

Penetration Funding Set at $1 Billion

Almost $1 billion has been poured into development of penetration aids for U.S. missiles during FY 1962 through FY 1965. Secretary McNamara told the House Armed Forces Committee in testimony released last week: "Though they may not represent a new weapon system to some, they have been deployed and I can assure you that they represent an enormous increase in U.S. deterrent power."

Hypersonic Craft With SCRAMJET Forecast

Air Force is studying the possibility of using SCRAMJET hydrogen-burning, supersonic combustion ramjet engines to power hypersonic aircraft capable of achieving orbit. Gen. Bernard Schriever, head of Air Force Systems Command, suggested development of an 8,000-mph research aircraft with an eventual orbital capability to the Fourth Symposium on Advanced Propulsion Concepts last week in Palo Alto, Calif. Such a research vehicle also could lead to development of recoverable launch vehicles, he noted.

INDUSTRY

Two Firms Win Lifting-Body Awards

McDonnell Aircraft Corp. and Norair division of Northrop Corp. have been awarded $150,000 NASA contracts for studies of lifting-body re-entry vehicles. Sole mission of the vehicle to be considered will be the basic research involved with re-entry of a manned lifting body from orbital flight.

Uprating of Little Joe II Proposed

General Dynamics/Convair is proposing an uprating of the *Little Joe II* launch vehicle by adding a *Minuteman* upper stage. Such a vehicle could have a payload of up to 2,000 lbs. in a 100-mile orbit. One possible mission would be flight tests of the *Voyager* spacecraft landing capsule.

Voltage Hike Blamed in Nerva Shutdown

Apparent cause of premature shutdown of AEC's Nerva nuclear reactor during a test on April 23 was a rapid voltage increase in a non-nuclear component. NRX-A3 operated for eight minutes at power before shutdown during a planned 15-minute run. The voltage increase in the turbopump rpm overspeed circuitry triggered automatic shutdown.

INTERNATIONAL

Rescue Mission Proposed to Eurospace

One suggestion put to Eurospace for U.S.-European space cooperation involves an international space rescue project which would employ a *Titan III-Gemini* combination as a standby rescue vehicle to go to the aid of astronauts in orbital difficulty. Proposal had White House approval.

Sweden To Buy More Seacats

Sweden plans to equip more naval vessels with the United Kingdom's *Seacat* guided missile. Further orders for the weapon have been placed with Short Brothers and Harland of Belfast.

New Zealand Site for Eclipse Probes

American sounding rockets will be launched from New Zealand by a U.S.-New Zealand team during a total solar eclipse on May 31. NASA, which proposed the experiment, will fly the rockets and supporting equipment Down Under. Experiment is aimed at the study of daytime electron densities in the lower ionosphere below the E-region. University of Canterbury scientists will prepare the launch pads and a scientific radio site.

$5.183 B Expected for NASA

The House of Representatives is expected to approve this week a total NASA authorization of $5,183,844,-850 for Fiscal Year 1966.

The final figure approved by the House Committee on Science and Astronautics last week was approximately $102 million below the original request of $5.26 billion. The total was increased, however, when the committee restored $27.2 million for the SNAP 8, 260-in. solids and M-1 programs, which were not included in the budget request.

Rep. Olin Teague (D-Tex.), second-ranking majority member of the space committee, said he does not expect the bill will undergo any further reductions on the House floor —although there may be some discussion of funds for the Electronics Research Center. Teague said the committee vote was unanimous and there was no attempt to make cuts beyond those recommended by the subcommittees.

Total R&D authorization for the space agency was $4,537,121,000, out of a requested $4,575,900,000. The committee approved $60,675,000 for total construction funds and $586,-048,850 for administrative operations. Original requests were for $74,000,000 and $609,400,000, respectively.

For the *Apollo* program, the House committee authorized $2,967,-385,000—$30 million below the budget request. Administrative operations funds for manned spaceflight were cut by $10 million to $279 million. Money for construction of facilities was trimmed by $2.84 million.

Total authorization for the Office of Advanced Research and Technology was $743,970,850, an increase of $3,369,850 over the request for $740,-601,000. The bill deleted a $10-million request for construction funds at the Electronics Research Center. The space agency still has $13.9 million from FY '64 and '65 construction funds for ERC, and it does not appear that NASA will be able to acquire title to any land in the Boston area during this fiscal year, a committee spokesman pointed out. The committee also cut $8.85 million from OART administrative operations funds.

In the Office of Space Sciences and Applications, total authorization came to $848,507,000—a reduction of $36.7 million from the budget request. The committee cut $6.2 million from funds for *Orbiting Astronomical Observatory*, $5.4 million from *Orbiting Geophysical Observatory*, $1.5 million from the *Surveyor* program, $1 million from *Lunar Orbiter*, $3 million from launch vehicle development, $15 million from launch vehicle programs, and $4.6 million from administrative operations.

Funds for Tracking and Data Acquisition were cut by $3.87 million.

The space committee also reduced the amount of funds that the space agency can transfer from research and development to construction programs from 2% to 0.5%. In addition, money that may be reprogrammed from one construction program to another was cut from $30 million to $10 million.

Retaliatory Ability Reaffirmed

United States missile targeting plans provide for destruction of all substantial military targets in both the Soviet Union and in Red China in the event of a mass nuclear attack on this country from either source.

This was the statement made in testimony before the House subcommittee on Defense Appropriations by Maj. Gen. John P. Lavelle, Air Force Director of Aerospace Programs. "Within the forces supported by this budget we do have the capability to target simultaneously the Red Chinese and the Soviets and a satellite area with survivable missiles after accepting the first strike, and can inflict unacceptably high levels of destruction," Lavelle said. "We also believe we can take out their government and their command and control capability, which in Red China is pretty highly centralized."

Brown Discounts EMP Threat

In House Armed Services Committee testimony just released, Dr. Harold Brown, Director of Defense Research and Engineering, gave new affirmation to his confidence that U.S. ICBM's such as *Minuteman* will be impervious to electromagnetic effects produced by very large nuclear explosions.

"The launch control centers are many feet underground," Brown emphasized. "As a result, we are confident that not only our missiles, but the electrical conductors which bring the launch signals to them will not be affected by 1-megaton bombs or 10-megaton bombs or by 100-megaton bombs. But in addition we are backing up this arrangement by having the capability to have the missiles launched by a signal sent from an aircraft. . . . So that even if the wires were to burn out, say, from electromagnetic signal . . . the missiles could still be launched."

AF Keen on 156-in. Strap-ons

With the 120-in. solid-booster program apparently safely on course following last Wednesday's final preflight rating test by United Technology Center, the Air Force is setting its sights on development of the 156-in. strap-on for launching the *Manned Orbiting Laboratory (MOL)* and other payloads from the Western Test Range (WTR).

If the Dept. of Defense approves building a *Titan III-C* integrate-transfer-launch facility at the Western Range, the Air Force will seek to size it for 156-in. motors to provide growth potential. The solid-motor assembly building at Cape Kennedy is sized for only 120-in. motors. The Air Force plans to do the necessary uprating for *MOL* polar-orbit launching at WTR.

Titan III-C can be uprated for *MOL* at WTR by adding two more segments to present five-segment 120-in. boosters, but sources close to the program say a number of technically good reasons point toward use of 156-in. motors. These include the desire to seek maximum growth potential. Spokesmen point out that two three-segment 156-inchers would double the payload that would be possible with two five-segment 120-inchers.

There also is the question as to whether segments of five- and seven-segment 120-in. motors would in fact be interchangeable, since segments for the latter configuration will require a slower burn time and therefore a different propellant mix and other changes, according to some spokesmen.

"When you look at the payload increase you're buying, and the fact that the whole spectrum of payload weights is going up in Air Force and NASA programs, the 156-in. strap-on seems to be more attractive from an economic standpoint," one Air Force source told MISSILES AND ROCKETS. "One of the biggest drawbacks is trying to standardize with the 120-in. size for an uprated *Titan III-C*. The idea is to have a standardized vehicle based on building blocks—with totally interchangeable segments.

Also, flight dynamics do not appear quite optimum with a seven- or eight-segment 120-in. motor."

Despite these comments, last week's static firing at Edwards AFB was an important milestone, giving the U.S. what is believed to be the world's first "flight-ready" large segmented solid booster capable of being configured for a wide variety of missions. The booster is flight-ready in that it is now ready for the first *Titan III-C* flight test in mid-June. Three flights are scheduled this year.

Body To Review Defense Cuts

Reconsideration of its $654-million cut in the military procurement and R&D budget requests was voted last week by the House Armed Services Committee.

Virtually wholesale restoration of procurement cuts and all but about $100 million (plus) of the $504.6 million in R&D reductions was restored in the bill marked up for reporting to the full House. The Senate has passed and sent to the House an authorization bill totaling $15.283 billion.

GE, LTV Gets NASA Pacts

NASA has modified a contract held by General Electric Co. to provide the design of electrical support equipment for *Saturn IB* and *Saturn V* launches. Amount involved in the modification is $40 million.

The space agency will also conduct competitive negotiations with Ling-Temco-Vought, Inc., and Lockheed Electronics Co. on a contract for support services at the Manned Spacecraft Center. First-year costs are expected to exceed $2 million.

Shots of the Week

The Soviet Union on April 21 orbited its first communications satellite, *Molniya I*, a non-synchronous device similar to *Telstar I*, launched by the U.S. on July 10, 1962. *Molniya* was used to relay television to Moscow from Vladivostok, 4,000 miles away.

- *X-15*, the NASA-Air Force rocket plane, was flown April 23 to measure heat caused on the craft's underside by air friction. Pilot was Air Force Capt. Joe Engle and the test was the 130th in the *X-15* program.
- The Air Force used an *Atlas-Agena* booster to launch a satellite of undisclosed type from Vandenberg AFB, Calif., April 28.

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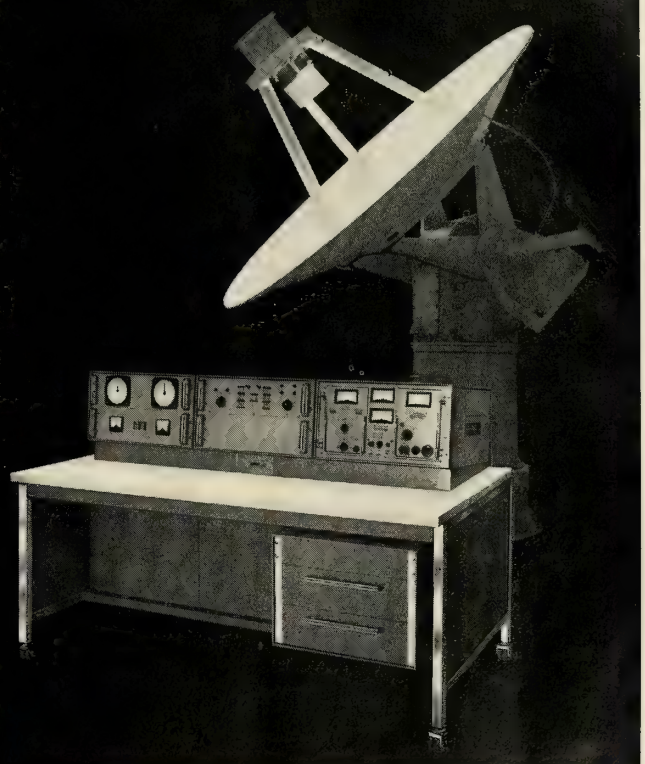

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Eurospace Debates Its Future

First meeting in U.S. stresses necessity for 'European NASA', a major project—perhaps Aerospace Transporter—and U.S. know-how

PHILADELPHIA—Eurospace delegates from 13 member countries are touring U.S. space facilities this week after a three-day meeting here to discuss ways and means of establishing an effective European space program.

At the closing session last Wednesday, the Europeans heard some blunt talk from their American counterparts, who chided them for not establishing an effective organization, for contemplating overly ambitious programs and for not doing enough to rally public support at home. This was the first meeting of Eurospace in the U.S.

Some of the Europeans showed themselves equally aware of Eurospace shortcomings. Three primary needs topped their list for promotion and control of the joint effort: establishment of a "European NASA"; selection of a significant, necessary, major space project; and the benefit of U.S. technological experience.

Hosted by the General Electric Co. during the conference portion of their two-week visit, 124 European delegates and 39 American attendees represented a cross-section of space experts from both sides of the Atlantic. Following the meeting the group began a tour of U.S. space facilities and industrial complexes.

A single European "NASA" capable of providing central coordination and control of space joint-ventures must evolve, many delegates said, if the European countries are to successfully implement a space program.

A practical, but significant, space project capable of exciting the imagination and generating the enthusiasm of the European citizen must be selected if he is to support such a program.

And delegates asserted that Europe wants American experience and methods.

● **Aerospace Transporter**—The major proposals for European space projects set forth at the meeting were contained in presentations by Eurospace President Jean Delorme of France; Dr. Erhard Loewe, a director of West Germany's Telefunken AG; and Lockheed vice president E. P. Wheaton.

Delorme and Loewe both sought to focus major attention upon development of an *Aerospace Transporter*, which was described as a potential European goal in a Eurospace report in 1964. Supporters of the concept, which is similar in scope to the ill-fated U.S. *Aerospace Plane* project, view it as a means to propel Europe into a significant manned spaceflight program as important to the Continent as the U.S. and Soviet manned space flight programs are to those nations. They feel the project will have sufficient stature to drum up the necessary public acceptance, enthusiasm and funding.

The *Aerospace Transporter*, basically a German project stemming from the work of Dr. Eugen Saenger, is currently viewed as having two piloted stages, according to Loewe. It would be able to operate from a European base, and be launched horizontally in aircraft fashion with a maximum acceleration of 2.5 G's. Total launch weight would be 200 tons. Each stage would be reuseable, up to possibly 50 times in two years. The vehicle would place the two-man payload (weighing 2½ tons and occupying 10 cu. meters) in a 180-mi.-high orbit.

Delorme believes it will take nothing short of a "European NASA" to implement a really large-scale program such as an *Aerospace Transporter*. While most attendees at the conference thought EuroNASA a good idea, few felt the concept could evolve in anything short of several years. Oddly

Eurospace Recommendations

EUROSPACE OFFICIALS at the conclusion of their April 26-28 meeting in Philadelphia agreed on five recommendations to the organization's council including a proposal to revitalize the standing Eurospace committee on joint European-U.S. cooperation.

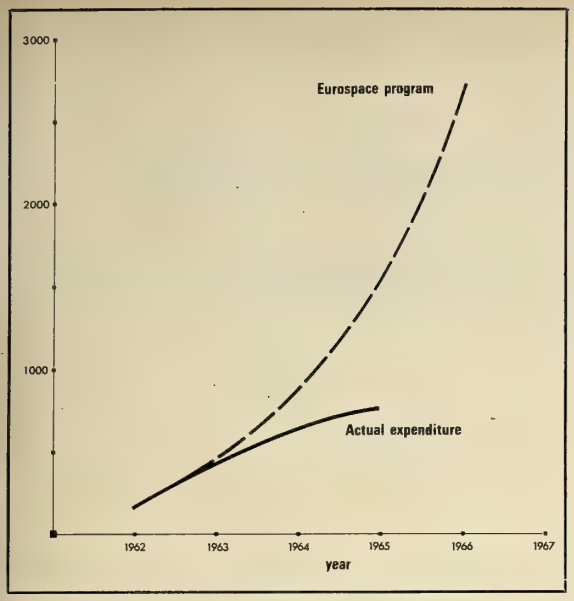
President Delorme told MISSILES AND ROCKETS this recommendation was the most important of the five. The standing committee, composed of industrialists, was established at the Eurospace meeting in Rome last spring, but has not been very active during the past year.

It was also urged that an effort be made to examine far more seriously the possibilities of setting up a European space agency-coordinating organization somewhat similar to NASA, often mentioned during the meeting here, which would consolidate existing programs and facilities. This will involve more frequent and detailed soundings in the coming year of governmental attitudes in all 13 member nations.

Still other proposals involve the beginnings of an active public relations program by European industry —and, it is hoped, governments—to develop public support for projected space activity; and the development of a detailed catalogue of U.S. space projects and R&D efforts being carried out by industry which might be of interest from the viewpoint of technical information exchange or licensing agreements.

Earlier, Mr. Delorme at a press luncheon expressed reported dissatisfaction among European firms with the types of licensing agreements thus far arranged with U.S. companies. The general complaint was that technology is sold only to a certain point, usually not reflecting the latest developments, and several years generally pass before a license is updated.

Delorme told M/R the next annual meeting of Eurospace would be held in Europe, possibly in June, 1966.



Overall European Space Budget
(millions of French francs)

enough, while Delorme, a Frenchman, has been a most ardent supporter of such an international agency, many attendees here felt that French nationalism would stand in the way of any such agency.

● **Satellites**—Delorme and Loewe both suggested continued European activity in communications satellites, but Loewe's proposals did nothing to strengthen the current or long-range operational goals of the existing Communications Satellite Corp agreement. Loewe suggested that a proposed French system of medium-altitude satellites might better serve the North-South traffic requirements of Europe and also bring better service to British Commonwealth nations.

Loewe also sees a high-powered TV broadcast satellite in Europe's future. Such a satellite would perform only TV broadcast functions, putting out kilowatts of power, and would not be part of a communications satellite, as is the case with all U.S.-proposed comsats. The demands of putting very-high-power equipment aboard would dictate a separate satellite. This project, Loewe told MISSILES AND ROCKETS, could be rather political, since such a satellite and the availability of high-power TV transmitters not limited by short transmitting horizons would have obvious value as a propaganda tool in the continuing effort by both East and West to influence public opinion. In Germany, ground-based TV transmitters from both East and West face each other but are of course limited to line-of-sight operation.

Loewe also saw possibilities for European development of synchronous-altitude meteorological satellites, augmented by polar-orbiting craft possibly used for automatic data collection from ground stations.

● **No European comsat**—Loewe stood almost alone among Eurospace speakers in calling for a European communications satellite system to supplement the one being organized by the Comsat Corp. D. Kybal of Lockheed Missiles and Space Div. said a European system would violate the Comsat Corp. agreement signed by the various European countries and, more importantly, is not needed.

Kybal disputed Loewe's observation that the U.S. has need for only east-west communications while Europe's main need is for north-south lines. He estimated that between 10% and 14% of the total capacity of the Comsat system will be used by the U.S. for South American communications. If Canada is included, the figures goes to 20%, according to Kybal. On the other hand, Europe will use only about 6% of the capacity of the Comsat system.

Instead of trying to get two satellite communications systems, Kybal suggested, the Comsat global system should be made powerful enough to handle all the traffic generated.

Kybal encouraged European industry to participate in building the Comsat system. He quoted Article 10 of the Interim Committee of Comsat, which says that contracts for equipment should be let within countries in proportion to the quota of the participating Comsat members. He further suggested that European industry concentrate on the next generation of satellites to replace the "early, less sophisticated U.S. (communications) satellites."

W. R. Thomas, Elliott Automation, took issue with supporters of an *Aerospace Transporter* by observing that transporters "must go somewhere, do something." He advised that once realistic goals are established, then concurrent programs of electronics systems development and such could be gone into.

Thomas did not mention the use put forth by Eurospace for building the transporter: "for terrestrial hypersonic air traffic and . . . civilian close orbital flight . . . military applications."

While Thomas also came out against Europe setting up its own communications satellite system, he said Eurospace must nevertheless prove itself capable of doing communications satellite work. This is essential because Article 10 also prescribes that firms bidding for Comsat work must have the competence to do it. For this reason, France should launch its *Diamants* and Britain its *Black Knights*, Thomas said. He suggested that European companies design and launch communications satellites—but only to show competence, not to compete with Comsat.

● **Other craft**—Proposals by Lockheed's E. P. Wheaton for possible joint U.S.-Europe satellite undertaking included spacecraft able to serve as data-collection devices, possibly in conjunction with a U.S. system of meteorological satellites. Wheaton also singled out navigation satellites and geodetic survey vehicles as other areas of potential joint development.

● **Business opportunities**—Lord R. Caldecote, British Aircraft Corp., outlined the areas where U.S.-European collaboration might be fruitful. Pointing out that there will be very little difference, if any, between the U.S. and European ground stations needed for satellite communications, he suggested that U.S. companies begin licensing European countries to build such stations.

Caldecote said European industry needs good systems management from the U.S. on some of its projects. He stressed that it would be more realistic to have European companies as the prime contractors. Otherwise, European taxpayers would object, according to Caldecote.

M.P. Chaffiotte, Hispano Suiza, sees U.S. space simulators helping European industry develop its space hardware. "It would be more economical this way," he said, noting the complexity and cost of sophisticated simulators.

T. J. Gordon, Douglas Aircraft Co., Inc., took issue with earlier advice that European companies do what is within their technological grasp. Gordon advised pursuit of small space programs that "do require increases in knowledge and courage." He said this would be a "challenge" to Europe and would be good for joint efforts.

Gordon said that the prestige resulting from a successful European space project ranks in importance with pursuit of the project itself. The prestige factor may not be important to the U.S., but it does help to show off the ability and competence of European industry to the European taxpayers and authorities—a necessity for support of space projects. ■

JPL To Manage Voyager Lander

Boeing, General Electric and TRW/STL each awarded $500,000 contracts to do preliminary spacecraft design

by Hal Taylor

MANAGEMENT responsibility for the landing capsule for the *Voyager* interplanetary spacecraft is expected to be assigned to the Jet Propulsion Laboratory.

Since JPL already has responsibility for the *Voyager* spacecraft, its new duties will give it complete field center control of the project, which is expected to cost more than $1 billion.

The expected action was learned as the space agency announced that three firms—The Boeing Co., Aerospace Div.; General Electric Co., Missiles and Space Div.; and TRW/Space Technology Laboratories—have been selected for three-month preliminary design contracts for the spacecraft. In another contractual action, Avco Corp. was selected for two studies designed to provide data on the Martian atmosphere prior to preliminary design of the landing capsule.

Informed sources told MISSILES AND ROCKETS that while a final decision will not be made for a month, it is almost certain that JPL will be named to direct the capsule effort. There were previous reports that the management responsibility would be given to another NASA center in an effort to spread the work. The sources said that while the Langley Research Center will probably be involved with the re-entry aspects of the capsule development, JPL will be the only field center with development responsibility for the payload portion of the program.

● **Design teams**—The three-month spacecraft preliminary design contracts will be worth $500,000 each. Teaming with Boeing are Electro-Optical Systems, Inc., and Philco Corp.'s Western Development Laboratories. The General Electric industrial team includes Motorola, Inc., Military Electronics Div.; and Texas Instruments Inc., Apparatus Div. Teamed with STL is Douglas Aircraft Co., Missiles and Space Systems Div.

The three firms were among seven that submitted proposals Feb. 23. Following completion of the studies, one or two of the firms will be named later this year for detailed design program definition and development of prototype hardware. Current plans call for hardware development to be initiated early next year.

The spacecraft is expected to weigh 2,000 lbs. and the retro-propulsion module about 3,000 lbs. The spacecraft bus and the landing capsule are expected to be launched by a *Saturn IB/Centaur* combination in 1971. Tests of the spacecraft bus are planned for 1969.

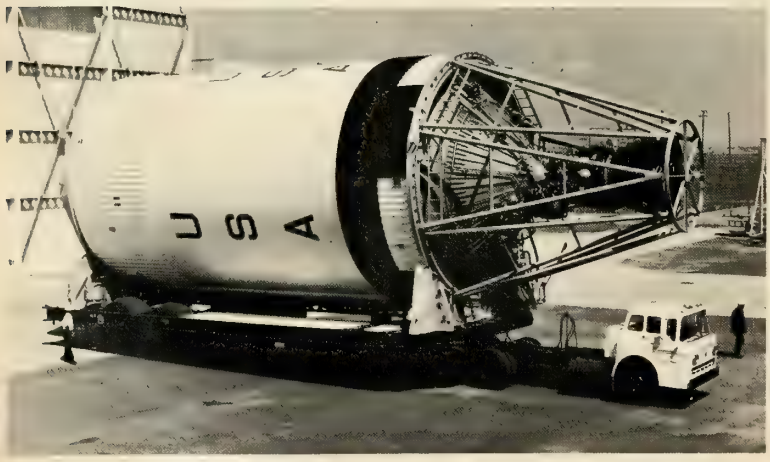
● **Lander described**—The capsule lander is expected to weigh up to 6,000 lbs. Preliminary design will be started later this year after data on the Martian atmosphere is transmitted back to Earth by the *Mariner IV* spacecraft.

The selection of JPL to direct the project is the first step in the capsule procurement schedule.

The Avco studies are not funded in the *Voyager* program, but are under the technical direction and funding of NASA's Office of Advanced Research and Technology and the Advanced Missions Office of Space Science and Applications.

The first study, a six-month effort costing about $300,000, will determine the feasibility of using a small, lightweight probe vehicle, which the NASA Ames Research Center has been considering, as an atmosphere measurement device during Mars entry.

The second contract, a seven-month effort costing about $600,000 is to study the feasibility of a concept under study by NASA's Langley Research Center. This is for an unmanned spacecraft to probe the Martian atmosphere and to return surface and atmospheric measurements after a survivable landing. The Langley Mars probe/lander concept involves a larger, more complex vehicle with a greater amount of instrumentation than the Ames atmospheric probe vehicle. ■



S-IVB Flight Stage Heads for Firing

FIRST FLIGHT-RATED Saturn S-IVB stage leaves Douglas Aircraft Co. Huntington Beach, Calif., facility enroute to Sacramento and a static firing. Stage will then go to NASA at Cape Kennedy to be used as upper stage on first Saturn IB flight vehicle. First unmanned Saturn IB is scheduled to be launched early next year.

MOL Proposals Include New Concepts

Bleymaier says different life support equipment, longer capsule possible; Gemini heavily favored over Apollo-X as basis of system

NEW YORK—Proposals for the *Manned Orbiting Laboratory (MOL)* now being evaluated by the Air Force Systems Command's Space Systems Div. contain new thinking in design of life support equipment.

Final briefings by *MOL* competitors were made last week at SSD headquarters in Los Angeles.

The approaches of all four companies—Lockheed, Boeing, General Electric and Douglas—recommend use of a two-gas environmental system. However, the choices range among oxygen/nitrogen at 7 psi, oxygen/helium at 7 psi, and the same two combinations at 5 psi with 70% oxygen. The latter is a new approach receiving some consideration by the Air Force.

Formal award of the contracts for *MOL* will probably be made in mid-June, Brig. Gen. Joseph Bleymaier told MISSILES AND ROCKETS during the Aerospace Medical Association meeting here last week. Bleymaier also revealed that refinement of structural design now indicates that the *MOL* capsule can be longer than originally conceived. While original thinking favored a capsule 10 ft. in diameter by 25 ft. long, it now appears that *MOL* will be 30-40 ft. in length, or perhaps longer. With the possibility of expandable structures, Bleymaier said, a maximum length of 70 ft. for the *Gemini* plus *MOL* is feasible.

• **Apollo-X too sophisticated**—It now appears certain that the *Gemini* will be the basis of the system. The *Apollo-X* is virtually being ruled out, it has been indicated, as having sophistication unnecessary and unsuitable for the *MOL* concept. However, some *Apollo-X* subsystems being developed for NASA may be incorporated into the *MOL* design.

One such possibility is the environmental control system developed by Hamilton Standard Div. of United Aircraft Corp. for the Lunar Excursion Module. This is said to be 87% adaptable for *MOL*, and the company is working with all of the *MOL* contractors except Lockheed, which is teaming with Garrett Corp. for the life support system.

A new approach—use of helium instead of nitrogen as a diluent gas—is finding increased favor with the Air Force. Two recent 30-day runs at the School of Aerospace Medicine in which subjects were exposed to a 44% oxygen, 56% helium atmosphere have done much to dispel some of the bugaboos associated with the gas.

Helium offers the theoretical advantage of decreasing the danger of bends upon decompression to a lower atmospheric pressure. This is an all-important consideration for *MOL* since the Air Force is very concerned with extravehicular experiments and reconnaissance operations.

• **Thermal problem discounted**—One of the biggest concerns about the helium atmosphere has been that the thermal conductivity of the gas—previously considered to be six times that of nitrogen—will require much higher ambient temperatures within the capsule for astronaut comfort.

However, in work reported at the meeting last week, Air Force School of Aerospace Medicine scientists said that at the one-half-atmposphere pressure considered for *MOL*—18,000 ft.—they could detect no changes in the thermal equilibrium of the subjects tested.

According to W. L. Epperson, heat loads were about the same at altitude in helium/oxygen as in normal air at sea level. It had no effect on the men's useful activity, as measured by a bicycle ergometer set at 100 watts, or 1.433 kilocalories, per minute.

Respiratory measurements, according to Capt. W. G. Robertson, indicated that the atmosphere is completely innocuous as far as pulmonary function is concerned. The only differences, he said, relate to the lower density of helium, increasing maximum breathing capacity.

Although one man was removed from the four-man test for medical reasons, his illness was due to a previous medical condition totally unrelated to the experiment. In fact, his breathing data and other such measurements were the same as the other subjects until his removal.

Communications tests showed that although there were differences in the voices in the helium/oxygen atmosphere from those in the nitrogen/oxygen there was by no means the difficulty in communications that has been postulated. The "Donald Duck" effect that occurs with use of helium at sea level pressures is absent at 7 psi.

Helium also may have a slightly more protective effect against fire than does nitrogen, researchers indicated.

• **Bends**—According to Dr. Thomas Allen, Physiology Branch Chief at the School of Aerospace Medicine, the 7-psi oxygen/nitrogen atmosphere, most often mentioned for *MOL*, will require 33 minutes of pure oxygen pre-breathing to avoid bends before transfer to pure oxygen at 3.5 psi. for extravehicular operation.

MOL pressure and atmosphere profiles—from normal atmospheres to *Gemini* 5-psi oxygen—have been simulated by Dr. Allen's group to evaluate the bends problem. Tests have been run using the same pressure, except with helium as a diluent, but results have not yet been reported.

Using the equations for the formulation of seed bubbles in the blood developed for this work, Allen said that the transfer from 5-psi 70%-oxygen/30%-nitrogen to pure oxygen at 3.5 psi would not cause decompression sickness.

Both nitrogen/oxygen and helium/oxygen combinations at 5 psi have been proposed for *MOL* and will be tested at the School of Aerospace Medicine this fall. Theoretically, such atmospheres would calm the medical fears of lung irritations in the long-duration use of 100% oxygen, but afford a safe ratio of decompression for extravehicular operation, which necessarily is limited to 3.5 psi pure oxygen by pressure suits. ■

Orion Research May Be Resumed

State of the art, possible military and non-military applications of concept outlined at propulsion meeting

by Willard E. Wilks

PALO ALTO, CALIF.—The Project Orion research effort, recently shelved when NASA claimed it couldn't justify participation in the program, highlighted a classified session at the Fourth Symposium on Advanced Propulsion Concepts here.

Papers by J. C. Nance, General Atomic Div. of General Dynamics; Lt. Col. John R. Burke, Air Force Headquarters; and G. R. Woodcock, Marshall Space Flight Center, outlined the technical status, potential military applications and possible non-military uses of the nuclear pulse concept.

Unclassified portions of the presentation included the report that the payoff/risk ratio of the development task probably is one of the best in aerospace history.

A secret paper treated in detail three selected missions and the associated conceptual systems, including one Earth-surface-stationed system and two space-stationed systems, utilizing the Orion propulsion concept. The April 26-28 symposium was sponsored by the Air Force and United Aircraft Corp.

There is some indication that work may be resumed on the Orion approach in one form or another.

● **Electrothermal propulsion**—Dr. Richard C. John, manager of the plasma research department, Avco Corp., reported on "Recent Advances in Electrothermal and Hybrid Electrothermal-Electromagnetic Propulsion." The paper, a cooperative effort with Stewart Bennett, chief of the division's plasma physics section, presented experimental and analytical results on performance and practical application of electrothermal and electromagnetic space propulsion engines. Engines considered included the resistojet, the conventional arc jet and the hybrid arc jet.

The wide-range of specific impulse, from a few hundred seconds or the low-power pulsed ammonia-fueled resistojet to more than 10,000 sec. for the hybrid arc jet, makes possilbe a variety of missions, including satellite orbit and attitude control, upper-stage propulsion for a planetary orbiter or a lunar ferry, space-station drag cancellation and satellite mapping missions.

John reported that recent advances in development of eight solar cell power supplies strongly suggest that application of electric propulsion to a variety of missions does not have to wait for development of nuclear-electric power systems such as the SNAP 50, but can proceed in the immediate future. The Avco work has been supported by NASA contracts.

● **Alfven wave propulsion**—A paper by Dr. Robert A. Gross, entitled "On Alfven Wave Propulsion," reported on an effect that may offer unique application. Since electrically conducting satellites moving through the ionosphere may generate Alfven waves, it has been suggested that using a source of electrical power to reverse the current flow could convert the Alfven wave mechanism to a propulsion system. Dr. Gross is professor of engineering sciences at Columbia University.

M/R Honors Authors

WINNERS of the annual MISSILES AND ROCKETS awards for the best unclassified papers presented at the Fourth Symposium on Advanced Propulsion Concepts are Dr. Richard C. John, research and development division, Avco Corp., and Dr. Robert A. Gross, professor of engineering sciences at Columbia University.

John's paper, "Recent Advances in Electrothermal and Hybrid Electrothermal-Electromagnetic Propulsion," won the first place award of $150. Gross will receive $50 for placing second with a paper entitled "On Alfven Wave Propagation."

The winners were chosen by ballot by the more than 200 officially registered for the April 26-28 conference held in Palo Alto, Calif.

Preliminary investigation supported by the Air Force suggests resulting thrusts may be competitive with ion engines.

A concept for a hypersonic ramjet engine that would enable an aerospace plane to take off and fly into space essentially like an aircraft was described by Dr. Antonio Ferri of General Applied Science Laboratories in a closed session. The vehicle would be aided on takeoff by a jettisonable rocket. It would reach near orbital velocity at 30 to 40 miles. At that point, it would use a "kick-in-the-perigee" approach to extend its orbit to higher altitude. This would involve successive passes through the perigee altitude to build up additional speed, with the engine operating only during passages through the atmosphere at the lower altitude.

● **Tribrids discussed**—An Air Force-funded applied research program to determine feasibility of the tribrid concept for application to rocket engines employing a cryogenic tripropellant system was outlined by J. R. Kielbach, United Aircraft Research Laboratories, in a classified paper.

The work has demonstrated feasibility of the concept, which uses a grain whose main ingredient is metal. Both liquids are cryogenic.

Despite the additional complexity of the tribrid approach, preliminary results indicate it represents the most practical metal injection scheme within the state of the art.

A high-specific-impulse, low-density application, the concept would be useful for upper-stage missions.

In his welcoming address, Maj. Gen. Don R. Ostrander, commander of the Air Force Office of Aerospace Research, noted changes in the military research and development posture since the last meeting. He said the changes, the result of more stringent requirements having to be met before systems can be approved for development, have placed more emphasis on research and exploratory development, resulting in a need for faster communication of ideas. ■

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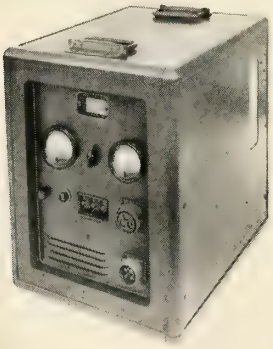

This new converter, now in production, changes 400-cycle power to regulated 60-cycle power. Converters also can be built to take 50, 60, or 400-cycle in *or* out. Or they can be designed to split the power so that 400 and 60-cycle outputs are available simultaneously.

Our static converters work well with standard piston engine generator sets – but when combined with Garrett-AiResearch 400-cycle gas turbine generator sets, they are the lightest weight and most compact dual frequency power sources available anywhere.

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Garrett static converters are rugged and dependable. The converter circuits have no moving parts, no bearings to fail or commutators to wear out. A proved circuitry technique insures SCR reliability.

Electronic components are mounted on unique cold plates for cooling, so that sensitive parts are never exposed to outside air contamination.

Need higher power? We also have systems up to one megawatt.

For more details on Garrett's solid state converter capability, write to: Clarence Frere, Manager, Electrical and Electromechanical Systems Sales, AiResearch Manufacturing Division, Torrance Facility, 2525 W. 190th Street, Torrance, California.

PERFORMANCE SPECIFICATIONS

INPUT:	400 cps ±5% 120/208 volts ±5%
OUTPUT:	60 cps ±0.5% 120 volts ±1% single phase sine wave, less than 5% total distortion. 15 kva continuous 22 kva overload

Garrett *is* experience

GARRETT

AiResearch Manufacturing Divisions
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Technical Countdown

ELECTRONICS

Twystron Promises High-Power Wide Bandwidth

A 10-Mw peak power S-Band twystron (type VA143A) with 10% bandwidth is being developed by Varian Associates. The company previously developed a version of this hybrid klystron/traveling-wave tube with 2-Mw peak power and 8% bandwidth. These bandwidth figures refer to the frequency range over which the power is constant to within 1 db, with constant drive. Prime applications for the twystron are broad-band radar and communications systems. Developers of the twystron at Varian believe they have just scratched the surface as far as the future of hybrid tubes is concerned. Bandwidths of 15-20% and much higher powers are now considered a reasonable goal for these tubes.

High-Powered S-Band Test Unit Developed

Peak powers of 225 Mw at S-Band and average powers of 700 kw have been achieved in a resonant-ring materials testing unit at Varian Associates. The facility enables ceramic metal seals, windows, and other waveguide components to be tested at powers that will ultimately be obtained in radar and communications systems. A VA839 klystron pushed up to 15 kw pumped the ring up to this record power. It was quickly shut off as X-ray dosimeter needles hit their stops.

New Field for Lumped-Circuit Ferrites

A new field of applications for ferrite devices is being pushed by Melabs, Palo Alto, Calif., by replacing distributed-circuit design with lumped-circuit components. Devices for frequencies of 50-60 mc have been developed that have only a few inches in their largest dimension. Formerly a very large block of ferrite would be needed. Melabs hopes to use devices of this type in IF amplifiers to remove the interaction effects between stages that arise because transistors are not unilateral enough.

Honeywell Building Ammonia Batteries

A liquid ammonia battery capable of performing for extended periods at temperatures down to −65° F will be produced by Honeywell, Inc., under a licensing agreement with G. and W. H. Corson, Inc., Plymouth, Pa., developers of the battery. The unit is a primary reserve type of power source and its size can range from that of a thimble to a conventional car battery. Its operating temperature extends from −65° to 165°, with an activation time of less than 50 milliseconds with setback activiation. Gas generator activation takes 250 milliseconds. With a life of more than 100 hours in some designs, the battery's energy density is 1.5 watt hours/cubic in. The operating voltage is 2 volts/cell and it has a shelf life in the inactivated state of more than 10 years.

ADVANCED MATERIALS

Simple Lubricant, Bearing Test Developed

The Alpha-Molycote plant of Dow Corning Corp. is marketing an inexpensive, easily operable test machine specifically designed to rapidly and accurately evaluate boundary lubricants and bearing materials. The Model LFW-4 press-fit machine tests bearing and lubricants for low-velocity applications by pressing an oversize pin into a bushing. The force required to move the pin is the friction and is read directly. The load on the bearing surface is the radial force exerted between the pin and the bushing and is a function of their dimensions and the elastic properties. The load can be varied by changing the interference between the pin and the bushing. The coefficient of friction is the friction force divided by the load. Additional information may be obtained from the Alpha-Molycote plant, 65 Harvard Ave., Stamford, Conn.

New Logic Methods from Magnetic Material

A magnetic material developed by a British subsidiary of International Telephone and Telegraph Corp. may result in new methods of computation and data handling. The material, developed at ITT's Standard Telecommunication Labs, will switch its field direction when only a small pulse is applied. The material has two stable states corresponding to an essentially single magnetic domain throughout. When the field is reversed, nothing happens until a critical nucleating field is reached—then a domain wall is suddenly formed. It rapidly sweeps through the material, reversing the direction of magnetization. But the coercive field required to drive this domain wall through the material is less than the nucleating field—so that the driving field may be reduced during the reversal process. With a suitable display system, a re-entrant hysteresis loop is obtained. In the best samples, the nucleating field has exceeded the coercive field by more than 100%, and no hysteresis loop is obtained until the applied field exceeds the critical value.

Maraging Motor Case Passes Fifth Test

A flightweight 156-in.-diameter maraging steel rocket motor case has successfully passed its third hydrostatic test at Lockheed Propulsion Co. In addition, this same motor case has been loaded and fired twice and is now being readied for its third loading. The case shows no deterioration after five separate occasions of experiencing pressures equivalent to full-scale firings. There are plans at the Lockheed Aircraft division to use the same case after the third firing. The 18% nickel-steel case was fabricated for Lockheed by Excelco Developments, Inc., from steel supplied by U.S. Steel.

SPACE SCIENCE

Solar Magnetic Fields Join Earth's

Data from the *Explorer XII* satellite and recorded by some 12 ground stations around the North Magnetic Pole indicate that a magnetic field around the Sun frequently joins forces with the Earth's magnetic field causing ionospheric storms and auroral activity. The coupling effect is believed to cause a great many of the problems in long-range radio broadcasting, create the auroral displays and allow an excess of particles through to bombard Earth. The evidence was detailed by Donald H. Fairfield, a graduate physics student in the Ionosphere Research Lab at Pennsylvania State University before the recent International Scientific Radio Union. Fairfield is studying under Dr. James W. Dungey, developer of a major theory of the magnetosphere and Earth-space interactions.

LEM System Readied for Checkout

Modularized Hamilton Standard environmental control unit is compact, might be suitable for MOL with little alteration

by Heather M. David

WINDSOR LOCKS, CONN.—First complete system hardware for the Lunar Excursion Module (LEM) environmental control system (ECS) will be shipped from Hamilton Standard Div. of United Aircraft Corp. to Grumman Aircraft Engineering Corp. next month for checkout testing in the LEM mockup.

According to E. Garaventa, LEM ECS program manager, the system is truly a second-generation effort incorporating many improvements over the control systems built several years ago for *Mercury* and later for *Gemini*. In addition, Hamilton Standard engineers point out, the system is 87% suitable for the *Manned Orbiting Laboratory*.

Among the new features designed at Hamilton Standard to be used in this system for the first time are:

—A porous plate water boiler in the heat exchanger, which eliminates the problem of back-pressure regulation of former boiler designs. It is self-regulating.

—A self-driven centrifugal water separator to separate water from the oxygen stream.

—Extended modularization eliminating tubing and tube fittings, permitting high-density packaging and light weight. Frame is titanium with a 0.004-in. wall thickness at some points. Modules can be checked out at Hamilton Standard and shipped to Grumman, increasing reliability.

The LEM system has the unique requirement among space vehicles that a normal mission calls for eight depressurizations. Another requirement that has dictated design is that weight must be jettisoned on the Moon before the LEM departs. Water supply, for this reason, has been divided into ascent and descent supplies, the descent tank being more than four times the total ascent supply, so that a minimum of water is left—just enough to get the astronauts safely back to the *Apollo* Command Module.

The system also must be compatible with suit design, since the personal life support system (PLSS) hooks into the main system to refuel its oxygen tanks. Other features, such as the lithium-hydroxide canister for carbon dioxide, are interchangeable for redundancy. This is not true of the Command Module environmental control system.

The LEM ECS also has been designed for very high environmental stresses, including high vibration amplitudes.

There are 105 components in the system, not including ducting, brackets and the like. Total weight, Garaventa told MISSILES AND ROCKETS is 227 lbs. without water, 402 lbs. with. Power consumption is 251 watts.

The model to be delivered to Grumman is a pre-production unit. Production is scheduled next fall. Hamilton Standard has already had to repackage the unit when it was found that the LEM hatch struck the system when it was opened.

● **Atmospheric revitalization**—Two recirculating oxygen loops—one for suit operation and one for the cabin—make up this subsystem. Two fans, which operate singly for redundancy, circulate oxygen through the suit circuit loop. The oxygen first flows through a water evaporator, which rejects excess heat. It then passes through an oxygen-to-liquid-coolant heat exchanger (glycol), which reduces temperature in the gas stream to about 45°. This results in condensation of moisture in the stream.

Flow is then routed through a manually operated diverter valve to one of two gas-driven water separators. These centrifugal water separators, arranged in parallel form, separate the moisture from the gas stream by means of a rotating drum. The water droplets are driven to the outside of the drum and collected in pitot tubes for pumping into the water-management section.

The oxygen flow is then passed through another oxygen-to-liquid coolant heat exchanger to heat the stream to desired suit inlet temperature and to reduce relative humidity. The valve which directs the flow to the suit can be reversed if necessary, or allow the astronaut to completely bypass the suit for the extravehicular mission. It is designed in such a way that the flow is not disturbed by one astronaut while the other remains on another flow mode.

Two fans circulate the air flow through the cabin at approximately five pounds per minute each. Although both are needed during some phases, one can be cut off when the mission allows.

In the normal operation with the cabin pressurized and both astronauts in the suit loop, the oxygen flow from the suit is discharged directly into the cabin, and the whole stream handled together. If there is an emergency, the oxygen can be kept in the suit loop and backflow into the cabin prevented.

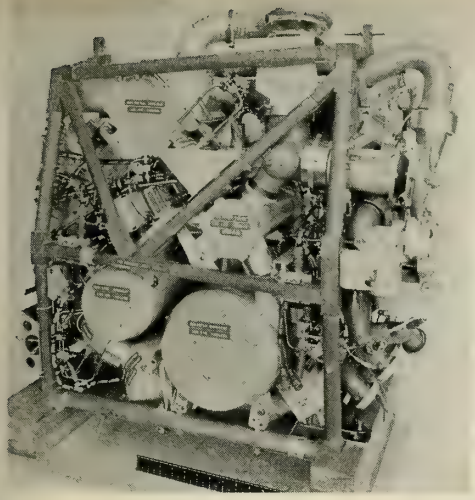
Next step is flow over carbon dioxide and trace contaminant removal canisters. Two canisters—one large and one small—of lithium hydroxide with activated charcoal are available. The smaller unit—for use when the large one is being replaced or in emergency—is identical to those used in the PLSS. Eight small canisters, two in backpacks, five in storage, will be carried in the LEM with two large canisters. The large canisters have a capacity of 41 man-hours each.

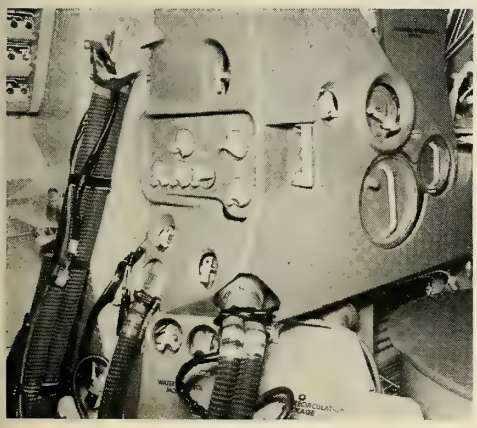
From the cabin fan outlet, the oxygen passes through another oxygen-to-liquid-coolant heat exchanger, where, as in the other cases, heat is rejected to the liquid coolant of the heat transport section.

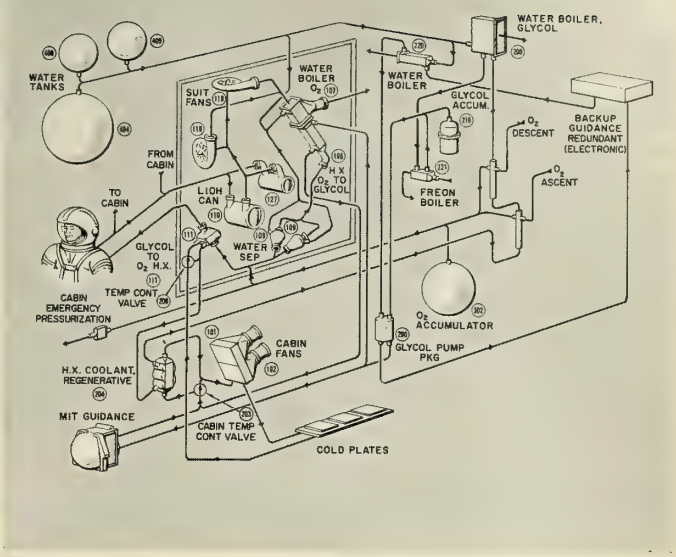
● **Oxygen supply and pressure**—Using cryogenic tankage and supply provided by Grumman, oxygen is stored at supercritical temperatures. It is converted to gas at 900 psi through a heat exchanger. It then passes through a filter and flow limiter to eliminate contaminations down to 40 microns.

The flow is then split into four possible directions—suit loop, cabin loop, PLSS refill and emergency pressurization system.

The emergency pressurization system is actuated when cabin pressure falls below 3.2 psi. A valve opens, and oxygen from a gaseous accumulator is dumped into the cabin. This tank, which holds 9.3 lbs. of oxygen, is enough to keep cabin pressure for two minutes.







TOP LEFT: Wooden mockup of environmental control system for Lunar Excursion Module shows high-density packaging, compact design and small size. Ruler used for reference is 12-in. long. Two canisters at bottom of photo are lithium hydroxide containers for control of carbon dioxide. BOTTOM LEFT: Environmental control unit installed in LEM mock-up. Water control module is at bottom center and cabin air recirculation package is at bottom right. ABOVE: Schematic of LEM system function.

After use, it is recharged slowly through the normal oxygen supply loop.

Oxygen flow through the cabin is controlled by a solenoid operating valve, regulated by the cabin pressure switch. Manual override also is possible. Two cabin outflow valves provide for cabin dumping and pressure equalization between the LEM cabin and the *Apollo,* and also prevent excessive cabin-to-ambient pressure differentials.

• **Heat transport**—Careful balance is maintained to utilize the different temperatures of the atmosphere revitalization section—cryogenic fluids, electrical equipment and water-evaporative heat sink.

There are three pumps in the main heat transport loop, plus one for redundancy. They pump a glycol solution through the Massachusetts Institute of Technology guidance system and other electronics equipment, with another path going to the suit loop heat exchanger. The flow paths are then joined through a regenerative heat exchanger and then to the cabin heat exchanger. It then passes through additional electronic equipment to absorb more heat.

Part of this heated coolant is then siphoned off to the suit loop to heat inlet suit temperatures to the proper level. This flow can be controlled manually, giving the astronaut an additional means to regulate his suit temperature.

Main flow goes through a regenerative heat exchanger, where some heat is rejected. From this exchanger it flows to a cryogenic unit, where heat is transferred to cryogenic fluids.

System-generated heat is then handled in a water boiler of Hamilton Standard design. This unit, called an HS sublimator in the *Saturn* space vehicle, is of porous plate design and is completely self regulating. The *Apollo* suit life-support systems (M/R April 26, p. 26) also has these devices.

Basically, the unit freezes water on one side. Heat ducted into the unit melts it, changing it to steam. This allows the flow to begin again. Thus, in effect, it turns itself on and off, since the more heat it is exposed to the more frequent the cycle. Pressure control is built in, so there is no problem of back-pressure. It has an additional feature of having no moving parts.

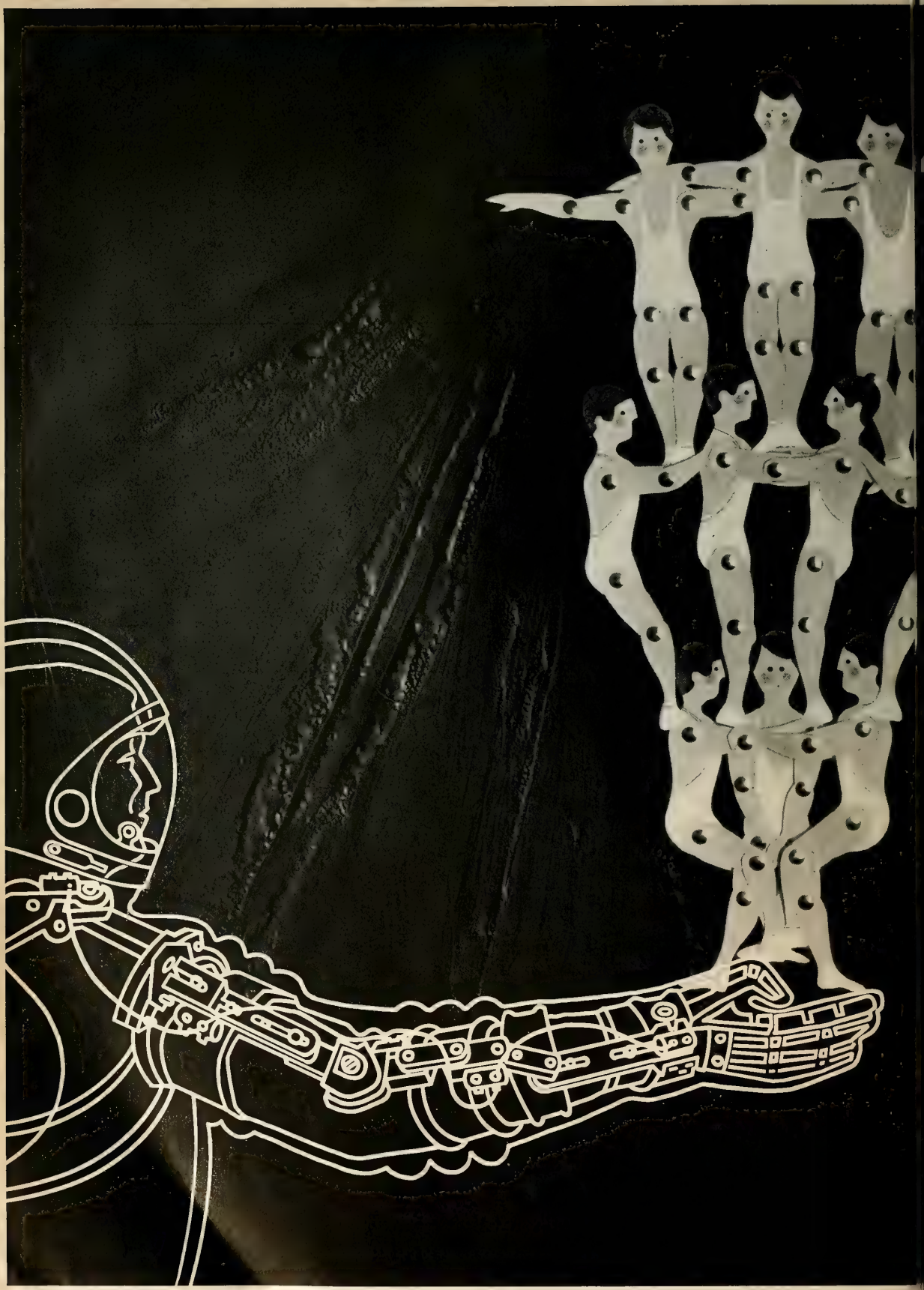
The steam is discharged into the space vacuum.

There also is an emergency heat-management loop that operates independently for emergencies, during which only vital equipment and functions are provided.

• **Water management**—Water is provided for drinking, for refilling the water-cooled undergarment for the *Apollo* spacesuit, for water evaporators and pressurization of the emergency heat-management loop.

There are three water tanks, separated so that ascent weights may be lightened by leaving descent materials. The descent tank, which will operate throughout landing and the lunar mission, carries 322 lbs. of water. Two ascent tanks weighing 40 lbs. each will be all that remains on the LEM when it takes off from the Moon.

Each tank has a bladder externally pressurized with nitrogen. Water is positively expelled from the tanks. ■



LIFT A TON WITH EITHER HAND?

It's simple if you're outfitted with a Man Amplifier, a framelike powered exoskeleton that fits the human form. Now under development, a Man Amplifier might well be powered by Kearfott actuators. One use foreseen for the system is to make it easy for astronauts to work in the vacuum of space.

Our rotary and linear actuators have already solved some of the most far-out problems in control system design.

ELECTROHYDRAULIC ACTUATORS. Kearfott Hydropacks were the first fully self-contained, modularized, plug-in hydraulic actuator systems to become standard hardware on an operational missile. These compact units are installed right where the muscle is needed and energized from the nearest electrical outlet. We supply six Hydropacks for each of the Army's Pershing missiles, and more than 360 of these units have flown without a reported failure. The same principle (a closed loop system with pump, sump and actuator) is being applied in the Navy's ASMS missile.

Kearfott makes other novel hydraulic actuators which are not self-contained. One is being used for radar platform stabilization in the RF4C. Another acts as the steering muscle in an LVH hydrofoil boat. Still another helps out in a helicopter flight control system. These actuators have a unique ball-socket design which eliminates misalignment and allows rigid mounting of the actuator.

ELECTROMECHANICAL ACTUATORS. These, too, are seeing service in a wide range of applications. A non-reversing actuator is used in the XC 142 to control pitch and trim of the horizontal tail surface. Another positions the tail prop. Both actuators operate during the transition from horizontal to vertical flight. Electromechanical actuators are functioning in the stability augmentation system of the CH46A Sea Knight helicopter, holding it steady even during a hasty unloading under combat conditions.

As for esoteric space applications—four Kearfott actuators were used on the Mariner 4 to control steering during its mid-course maneuver. Two others in the Apollo spacecraft transmit considerable torque through a hermetic seal, opening and closing the astro-sextant hatch and the crew hatch.

AN IMPARTIAL VIEWPOINT. Having both types of actuators leaves us very open minded about the choice of one or the other. When it comes to preferences, we choose the one that solves the problem at least cost. It's easy enough to debate the merits of electromechanical versus hydraulic actuators, but there's no debating the merit of having satisfied customers—and we're most fortunate in this respect. We'd be glad to help you make a selection if the need ever arises. We'd be more than happy meanwhile to send you literature that will provide some enlightenment on the subject.

KEARFOTT DIVISION
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Little Falls, New Jersey

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Million-Pound-Thrust Hybrid Proposed

UTC analyses indicate such a booster could be demonstrated within three years at a cost of less than $3 million

by John F. Judge

SUNNYVALE, CALIF.—A large hybrid booster rocket in the million-pound-thrust class could be demonstrated within three years for less than $3 million using refurbished large solid hardware and current liquid rocket test facility tankage.

Intensive analyses covering the cost/effectiveness potential of large hybrid boosters, developed by the United Technology Center division of United Aircraft Corp., also indicate that:

—Practical predictions of the dollar-development of such large hybrids would be approximately 25% of a comparable RP-1/LOX liquid engine.

—The hybrid would cost about 10% as much as a comparable liquid hydrogen/LOX engine.

—The hybrid program could be done for 50 to 60% of the cost involved in comparable large solid rocket development in the 1 to 1.5-million-lb. thrust areas.

● **Commonality of Technology**—Russell F. Thielman of UTC emphasized that the cost study does not imply that hybrid technology is at the same point as either large liquid or large solid boosters. The basic proof of large hybrid feasibility rests solely with scaling up the present technology.

Since there is a significant utilization of both liquid and solids technology in hybrids, Thielman says no development problems can be identified in scaling up hybrids.

The problem of motor insulation, thrust vector control and nozzle design have been solved during the initial development of large solid boosters. All that remains, says Thielman, is to scale hybrid technology up successively to 500,000- 1,000,000- and 5,000,000-lb.-thrust levels in order to demonstrate the performance levels available.

"There are no technical reasons", continues Thielman, "why combustion should not remain completely stable, why fuel utilization over 99% cannot be duplicated nor why combustion efficiency over 95% cannot at least be maintained (M/R, Nov. 9, 1964; Special Report on Hybrids).

The UTC analysis avoids direct quantitative comparisons among liquid, solid and hybrid development, production, and usage costs. The basis of comparison is relative and this approach was chosen at the risk of degrading the significance of the study results solely to avoid prejudiced or defensive reaction.

In his analysis, Thielman concludes that the LOX or N_2O_4/CH_x hybrid propellant systems provide a performance/cost ratio at least equal to current conventional liquid technology.

● **Some advantages**—In addition, the hybrid approach to large rockets has the following advantages:

—Hybrid propellant systems are non-detonable. This characteristic provides a major cost reduction in handling and checkout since the propellant systems under consideration have a TNT equivalence of zero. Large boosters can be launched from existing pads without involving the usual explosive quantity-distance requirements.

—Hybrid propellant systems will not support uncontrolled burning. The basic combustion process in a hybrid is totally different from that in both liquid and solid systems. Excess oxygen resulting from a pad incident would quench the flame zone and cool the fuel surface.

—Hybrid fuels require no special facilities or handling. They can be mixed in any commercial apparatus and in open air with complete safety.

—Wide variations in ambient temperature produce no change in burning rate. Unless the fuel is deliberately made thermally radiative through metal additives, the burning rate is dependent on the oxidizer flow rate and is not a function of pressure.

● **Simplicity equals savings**—The basic simplicity of a hybrid is a crucial element in the cost picture. The thrust chamber uses conventional solid rocket technology but eliminates the thrust-termination and ignition systems of the solid.

Throttling has been demonstrated in ratios as high as 50:1 and can be achieved by simple oxidizer flow control. Thrust vector control can be attained through differential throttling either across a motor cluster or across the ports of a single motor.

The liquid portion of a hybrid motor uses easily fabricated components. Thielman says considerable latitude is possible in oxidizer delivery, which reduces pumping or pressurization requirements. The inherent stability of hybrid combustion leaves design room in the inert component area.

Thielman says the whole question of reliability is argumentative in the absence of extensive flight data—and hybrids have not yet been flown in significant numbers.

But the concept itself contains several elements leading to a high degree of inherent reliability. These include a minimum number of major failure modes resulting from using a single liquid phase and crack-, pressure- and temperature-insensitivity of the solid fuel.

The combination of high delivered

Hybrid Elements

A HYBRID ENGINE consists of a liquid oxidizer, a solid fuel and associated hardware. In its basic form, the liquid oxidizer is valved into a chamber containing the solid grain. Ignition is usually hypergolic.

Neither propellant will support combustion by itself in a true hybrid. The solid fuel portion resembles a solid rocket in that the combustion chamber is within the solid grain. The liquid sections are similar to tankage and pumping elements in a liquid engine. There are no unique components in a hybrid. The major difference is the use of liquid-solid combination and the particular combustion process resulting from this. A comprehensive report on hybrid technology appeared in MISSILES AND ROCKETS, Nov. 9, 1964, p. 31.

NEW

INSTRUMENTATION TELEVISION CAMERA

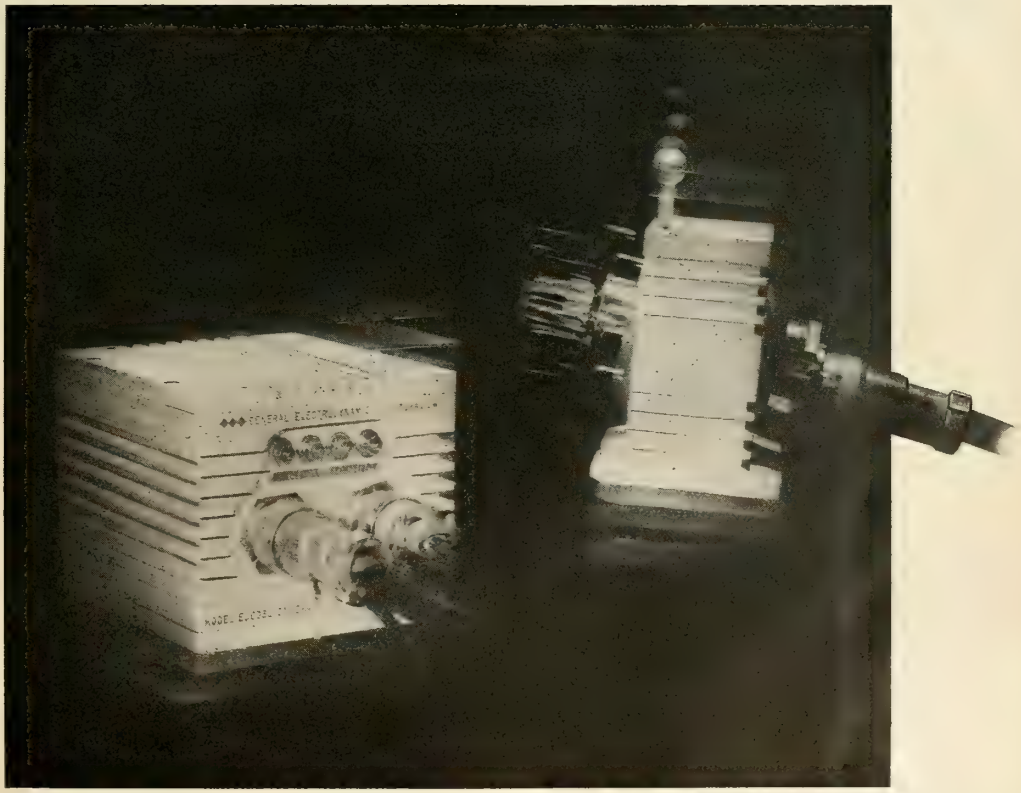
OPERATES IN EXTREME ENVIRONMENTS

The ED 6038 miniaturized instrumentation television camera was designed by General Electrodynamics Corporation to operate in the extreme environment existing within the engine compartment of the largest space boosters, such as Saturn. The high quality pictures produced during this severe environment will provide direct, real-time observation of events while they are happening.

This compact, light weight camera is available in a number of configurations with a wide selection of accessories from General Electrodynamics.

ENVIRONMENTAL CHARACTERISTICS:

20g RMS
60g RMS for 5 sec
20 cps — 2000 cps random
Shock: 100g for 11 ms
Altitude: Space environment
Acoustical Noise: +175 db
Temperature: —10°C to +71°C operating
—10°C to +125°C non-operating
Explosion Proof



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specific impulse and mass fraction permit the use of conservative design stresses and non-sophisticated inert materials.

The mechanical properties of hybrid fuels are far superior to those of the conventional solid booster propellant.

Finally, says Thielman, it is practical to "idle" the booster on the launch pad at a low thrust level and thoroughly check out all operational performance prior to committing the vehicle to flight. Should a fault be detected, the motor is simply shut off.

● **Beyond development**—Production costs are based on five essential tasks for all systems. Thielman lists these as engineering support, fabrication, inspection, assembly and test (see box for detailed comparison).

Usage cost elements isolated in the UTC study covered:

—subassembly of propulsion system components;

—shipment at launch site;

—inspection and acceptance testing at launch site;

—subassembly integration into stage;

—checkout and launch.

Based on the 1-million-lb.-thrust-level figure, the tasks associated with liquid systems turn out relatively high because of the large number of complex components in the system.

Thielman says the hybrid loses some of its advantage over the solid on a cost basis in the usage area because of the liquid portion of the system. But there are two factors of flexibility in this area that help minimize hybrid usage cost. These are the possible utilization of storable oxidizers rather than cryogenics and the distinct possibility of on-site fabrication, which eliminates shipment and source inspection and acceptance costs.

Since the relative development, production and usage costs cover only one aspect of cost comparisons, Thielman translates the relative performance levels of the three technologies into cost equivalence.

In doing this, only production and usage costs are used, with development considered as a sunk cost. Development costs could be included and amortized against a program consisting of an arbitrary number of flights.

The UTC study approach here included choosing a representative vehicle. Each vehicle consists of the same liquid upper stage and the respective booster systems. Differences in Isp and propulsion system mass fraction were taken into account.

Thielman says the key point in this aspect of the analysis is that the hybrid specific impulse and mass fraction in conjunction with total cost produce a cost/effectiveness level significantly better than the comparable solid and almost half that of the comparable liquid.

Thielman did not limit the study to the 1-million-lb.-thrust area. Moving on up to very large boosters led to the conclusions that the cost advantage of the hybrid increases with increasing thrust or impulse and that it is more cost/effective to produce a given thrust through motor clustering.

● **Potential applications**—To pin down those areas where the applications of hybrids makes sense, Thielman begins with six reasonable assumptions.

—The national space effort will proceed undiminished after *Apollo;* lunar and orbiting space station development will be emphasized; the Air Force will verify man's usefulness in space and be assigned a manned space mission; larger interplanetary payload ability will be required; lunar base and space station utilization will require economical shuttle vehicles; and cost/effectiveness will increase in importance.

The analyzation identified a need for payloads of 500,000 and 1-million lbs. in low earth orbit. Military requirements can be projected to the 60,000- and 80,000-lb. payload class.

In evaluating the applications of hybrids to large payload vehicles, the UTC study considered the replacement of existing vehicles to achieve greater cost effectiveness. The *Saturn* series was included here.

Thielman says that even though greater cost/effectiveness could be at-

BELOW LEFT: Unit production cost—liquid rocket.
BELOW RIGHT: Unit production cost—solid rocket.
BOTTOM: Unit production cost—hybrid rocket.

LIQUID COMPONENT/SUBSYSTEM	% TOTAL COST
Thrust Chamber Assembly	39.2
Turbopump & Gas Generator	25.1
Injector Valves	6.2
Propellant Lines & Valves	9.0
Fuel Tank	2.8
Oxidizer Tank	4.8
Tank Pressurization System	3.0
TVC System	2.8
Stage & Motor Support Structure	5.8
Propellant	1.3
	100.0

SOLID COMPONENT/SUBSYSTEM	% TOTAL COST
Motor Case Segments	21.4
Nozzle	10.0
TVC Assembly	21.2
Forward Closure	9.8
Aft Closure	8.0
Support Skirt	5.0
Ordnance	2.0
Propellant	15.5
Attachment Hardware	4.0
Miscellaneous Structure	3.1
	100.0

HYBRID MOTOR CHARACTERISTICS

I_{sp}, Del 275 Sec
Thrust 1,000,000 lb
t_b 120 Sec

Inert Weight 80,000 lb
Mass Ratio 0.870
Propellant LOX/CH_x

COMPONENT/SUBSYSTEM		% TOTAL COST
Motor Case and Closures	$ 600,000	27.6
Nozzle	250,000	11.5
TVC Assembly	110,000	5.2
Support Skirt	125,000	5.8
Turbopump & Gas Generator	550,000	25.3
Propellant	65,000	3.0
Oxidizer Tank	240,000	11.0
Oxidizer Line & Injectors	55,000	2.6
Tank Pressurization System	70,000	3.4
Stage & Miscellaneous Structure	100,000	4.6
With Conventional Solid Motor Hardware	$2,165,000	100.0
Cost Optimized	$1,750,000	

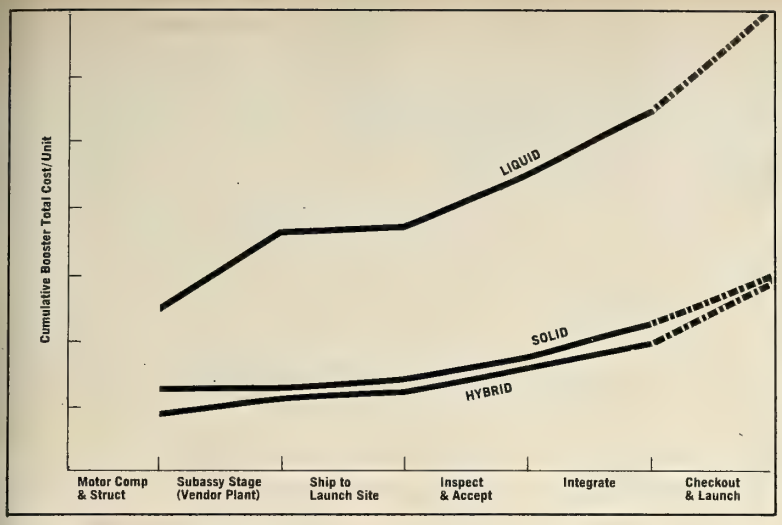
THE UNIT PRODUCTION costs for all three systems studied at UTC are based on an assumed production run of 100 motors in the million-pound-thrust class. Thielman points to five significant cost differences between the hybrid and the other two systems.

The motor case and closures are 29% of the total cost of the hybrid because of its shorter length and lack of segmentation. The thrust vector control is just 5% of the hybrid cost since the pressurized oxidizer available at the turbopump can be used.

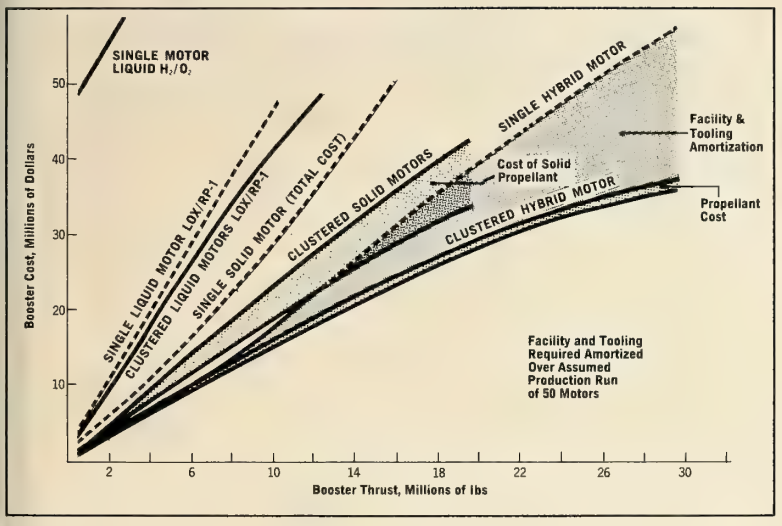
The use of only a single impeller oxidizer pump and smaller gas generator in place of the more complex assembly in the liquid contributes just 25% of the hybrid production cost. The highly simplified and non-explosive characteristics of the hybrid fuel with LOX bring this cost down to 3% of the hybrid's total against some 15% in the case of the all-solid motor.

The presence of a single liquid system in the hybrid using non-critical, simple components results in a 3% bite as against 15% for the liquid engine.

Further significant savings can be achieved through cost optimization in the hybrid—such as degrading the stage mass fraction through low-cost inert component substitution while adding propellant.



USAGE cost elements (relative).


SINGLE MOTOR LIQUID H_2/O_2
SINGLE LIQUID MOTOR LOX/RP-1
CLUSTERED LIQUID MOTORS LOX/RP-1
SINGLE SOLID MOTOR (TOTAL COST)
CLUSTERED SOLID MOTORS
SINGLE HYBRID MOTOR
Facility & Tooling Amortization
Cost of Solid Propellant
CLUSTERED HYBRID MOTOR
Propellant Cost
Facility and Tooling Required Amortized Over Assumed Production Run of 50 Motors
Booster Cost, Millions of Dollars
Booster Thrust, Millions of lbs

CLUSTERED vs. single motor cost.

tained, the large sunk development costs of the *Saturn 1-B* and *Saturn V* vehicles moves the breakeven point to 150 launches for the *1-B* and 40 launches for the *Saturn V*.

The launch frequencies now contemplated extend the break-even point beyond a reasonable period of time. It makes better economic sense to extend the usage and payload ability of these vehicles—spreading the initial development over a larger base.

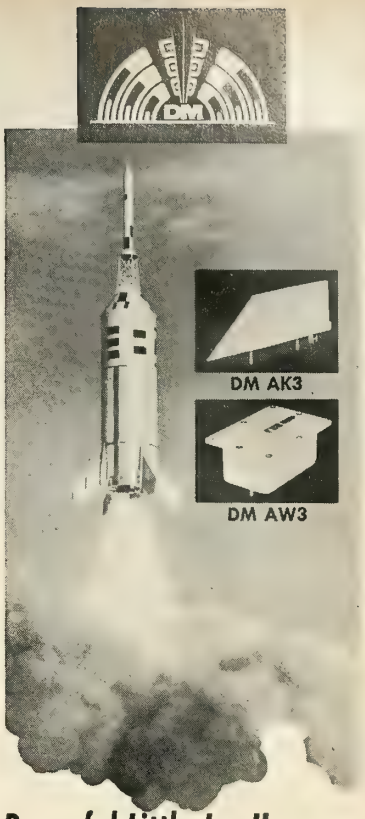
● **Cost/effectiveness justification**—The 120-in. solid now being developed by UTC for the *Titan III-C* turns out to be superior to a hybrid as a *Saturn 1-B* stage zero on a cost/effectiveness basis. This is because the motor is fully developed.

But the break-even analysis in the 156-in. and 260-in. solids areas indicate that cost savings start with the first hybrid launch.

The hybrid offers a major advantage in cost/effectiveness, says Thielman, when applied to uprating the *Saturn V*. Development of a 5-million-lb. thrust hybrid module can be justified economically by the growth potential it offers the *Saturn V*.

UTC considers two cases of uprating the *Saturn V*. In one the zero stage would consist of four 5-million-lb.-thrust hybrids. The second case involves increasing the *Saturn V* payload by adding a first stage of eight 5-million-lb.-thrust hybrids. This would be in addition to the S-1C stage.

An added bonus occurs by developing a standard hybrid thrust module. This could then be applied to military needs as a *Titan-V* vehicle—two 5-million-lb.-thrust strap-ons with the *Titan III-A* core for a payload of about 60,000 lbs. in low Earth orbit. ■



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TV Camera To Monitor Biodynamics

Admiral Corp. converting video system to check body organ stresses; formerly used as launch-phase missile tracker

by Michael Getler

CHICAGO—A television camera and video processing system originally developed and used as a launch-phase missile tracking system is now being converted into a highly sensitive motion monitor to gather data on the displacement of human body organs under severe acceleration, deceleration and vibration conditions.

The system, being developed by the Admiral Corp. here under an Air Force contract valued at about $100,000, will be installed at the 6570th Aerospace Medical Research Laboratories at Wright-Patterson AFB in Dayton, Ohio, next month.

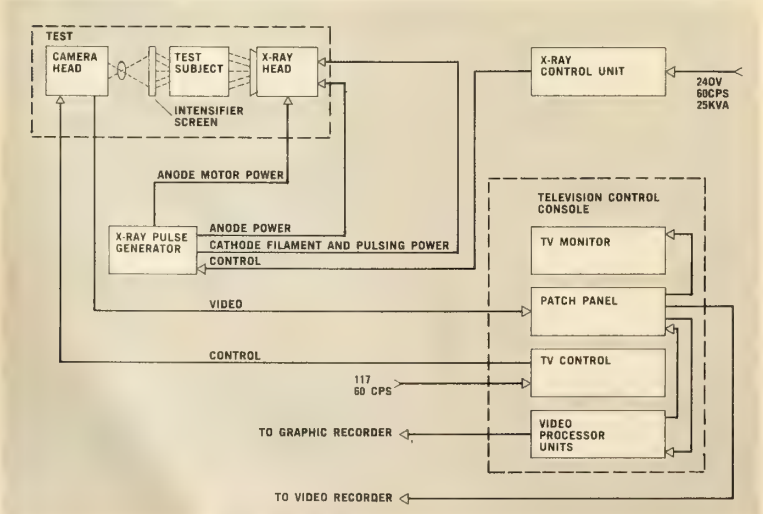
The system will be used in combination with a variety of test equipment at the Air Force lab, which will simulate motions normally accompanying such operations as multiple-degree-of-freedom space flight, re-entry, space capsule impact on water, ejection seat operations, and low-level bombing runs.

Specifically, Air Force doctors are expected to place early emphasis on the biodynamics of ejection seat operation and space capsule water impact problems, attempting to lessen the chance for fractured thoracic vertebrae during the former, and to measure such things as the amount of displacement of the heart, liver, and other organs, and the strain on their suspension ligaments experienced at capsule impact.

The Admiral system makes use of a very rugged pulsed X-ray tube, intensifying screen, and low-light-level TV camera, all capable of riding and operating in the same test chamber as the human subject throughout the test. The system hopefully will provide an answer to the previously insoluble problem of obtaining continuous data on the motion of otherwise inaccessible human internal organs during experiments, and also avoid the problems of influencing objects under test by implanting sensors.

Admiral scientists say that while X-ray has been used for certain types of tests in which there was also a requirement not to load the subject with attached sensors, the X-ray levels required have generally been too high, and also that equipment has been too fragile to be mounted directly aboard the equipment in which the subject is riding.

OVERALL block diagram of Admiral Corp.'s television camera and video processing system that will serve as highly sensitive motion monitor.



• **Shock-resistant equipment**—Project engineer at Admiral's Government Electronics Div., William Leysath, reports that the camera, screen and X-ray tube equipment to be delivered will be able to function in drop-chamber-type tests withstanding shocks of up to 25 g for up to 250 millisecs, and accelerations to 10 g's peak with a cut-off vibrational frequency at 30 cps.

The major elements of the system include:

—A low-light-level Admiral TV camera, employing a GE image orthicon tube, which is said to be sensitive enough to allow very low average pulsed X-ray levels to be applied to the subject. This, reports Admiral, allows observation over longer intervals with less danger of overdosage in comparison to X-ray/film recording systems. Leysath estimates that a single subject would be able to undergo about two test periods per month, receiving less than the 3 REM maximum in a 13-week period.

—A Machlett Laboratories, Inc.,

rotating anode X-ray tube head, specially shock-mounted and located on the side of the subject opposite the camera, will be used as the radiation source with a timing device to provide 1-millisec. pulses at the TV camera scanning rate of 60 cps.

—An X-ray intensifying screen is mounted in front of the camera so that the two actually form a single mechanical assembly. The screen, when excited by the X-rays, converts them to radiate in the blue, violet, and UV portions of the spectrum. This is also the portion to which the photocathode of the image orthicon is most sensitive. This eases the conversion of the X-ray image to a TV picture and also aids in focusing the camera's lens systems, something which is more difficult when using straight X-ray radiation, according to Admiral.

● **Also works in visible light**—Air Force scientists told MISSILES AND ROCKETS that another important advantage of the system is that it can work well in visible light which, in separate experiments, would allow pursuit of such information as response of the eye pupil to light stimulation and monitoring of other points on the body.

Admiral scientists point out that the conversion screen used is not the same as an X-ray image intensifier device, which they claim is too fragile to be mounted in this type of test equipment and also presents too small a field of view.

The Admiral system reportedly will allow viewing of a 20 x 30-in. area, roughly equivalent to the entire chest area on a subject. The system is also able to focus on areas as small as 3-4 in. in diameter for even higher resolution observation, and is said to include gating circuits that allow at least three smaller areas to be processed at one time.

The signal processing portion of what Admiral calls its "quantitative motion monitor" is that part of the system which basically was designed for the missile tracking role.

Original work began in 1958 with an Admiral contract for an optical missile tracking system for use at White Sands, N.M., where radar tracking difficulties were encountered because of clutter introduced by surrounding terrain.

The basic system involved a TV camera and video processing device, which provided proportional displacement signals related to the missile position vis-à-vis the camera field of view. The signals were used to control servo drives for another pedestal mounting photographic equipment. The system was refined by Admiral and was also demonstrated at Cape Canaveral, Wallops Island, and Vandenberg AFB launch sites.

● **Biomedical application**—Adaptation for biomedical use, according to Admiral, will provide position error signals proportional to the displacement of a selected target area from other reference points of sufficient contrast on the TV picture. The signals, in effect, represent the relative movement of these target points, such as heart edge, as compared to a reference point.

While precise definition of the internal target areas depends on the particular test situation, Air Force scientists told M/R that with this equipment they may be able to measure displacements of organs "to something approaching 1 millimeter."

Once exposed to the radiation, the image orthicon tube converts the optical image to an electron charge image on its target, which is then picked up by electron beam scanning. Thus, Admiral scientists explain, the optical image is converted to a video signal representing the original image in scanning time sequence.

The signal processing section takes the sequential video signal from the image orthicon, amplifies it, and mixes it with synch pulses needed to recreate the image. It then couples it to a display where it can be visually monitored. The video signal can also be simultaneously recorded for post-experiment viewing, something which is of major importance since peak shock test durations can be only milliseconds long. Admiral reports that the signal can also be fed directly from the camera or from video tape to a processor, which converts the video signal to electrical analog signals representing the X and Y axes displacement of the selected target.

The system is designed so that the overall target area is scanned from top to bottom 60 times each second. Leysath points out that the system is capable of producing roughly six complete pictures in 100 millisecs, which might be expected to correspond to the shock duration periods of major interest in certain tests.

The TV control console is remotely located in an X-ray-shielded area up to 250 ft. away from the test rig. The X-ray timing and operation control can also be located in the same general area, however the pulse generator must be installed within 50 ft. of the X-ray tube head, according to Admiral.

Air Force Project Monitor at Wright-Patterson, Capt. Edmund Weis, Jr., (MC), told M/R that if the equipment performs according to the engineering design figures, the system will provide much needed information "at lower dosage rates, with more pictures per second, better frequency response, and less of a logistics problem" than was previously possible. ■

space electronics

Radar Sounder Will Test Echo Validity

by Rex Pay

LOS ANGELES, CALIF.—An *Aerobee* sounding rocket will rise 125 miles above White Sands Missile Range in June to collect 30-cm radar echoes from the Earth in an attempt to improve the understanding of lunar and planetary radar returns.

It is hoped the experiment will enable better interpretations of lunar and planetary surface characteristics from the shape of the radar echoes they send back.

Initially, the data from the high-altitude rocket radar project will aid interpretation of Earth-based radar astronomy. Ultimately, however, the project will provide a basis for interpreting radar mapping of planets from fly-by or orbiting spacecraft.

The radar technology developed in the project is likely to contribute to design of radar instruments on future *Voyager* spacecraft. Radars of this type are being investigated by the Lunar and Planetary Sciences Section of Jet Propulsion Laboratory, developers of the scientific payload for the *Aerobee* flight.

Two *Aerobee* flights are planned for the project. They will provide calibration for planet and lunar radar echo interpretation by obtaining echoes from a target site with measured surface characteristics.

After the flight, physical samples of the terrain under the rocket's trajectory

will be subject to permittivity, loss tangent and penetration measurements at wavelengths of 30 and 3.3 cm. Water content, void ratio and chemical components will also be measured. Terrain profile studies will be made later.

● **Puzzling information**—Echoes obtained from the Moon and planets by Earth-based radars have been puzzling in the unexpected degree of smoothness they reveal on extra-terrestrial bodies. The question facing experimenters is whether this smoothness is real or whether the theory of radar echoes is incorrect.

Theory until now has been based on laboratory tests and on radar returns from aircraft at altitudes below 10 km. There is a major problem, however, in extrapolating from such short distances to solar system scales. In particular, the relationships of the size of the fresnel zone to the size of elementary reflecting areas is different. It is not possible to re-scale the situation by increasing radar wavelength, because this changes the relative geometry of the reflecting surface.

The JPL *Aerobee* experiment will attempt to break through this problem by obtaining the behavior of the radar echo as a function of distance from the reflecting area of the Earth's surface.

The geometry will roughly approximate that of lunar radar experiments. In these, a plane wave is reflected from the spherical Moon. This is a geometry that can be considered similar to that of a plane body reflecting a spherical wave of lunar radius. Even though the spherical wave from the *Aerobee* will have only reached a maximum of 200-km radius, the simulation will be correct to about an order of magnitude, and will be the first to get this close to the astronomical geometry.

Another important feature of planetary radar returns is the shape of the trailing edge of the returning echo. W. E. Brown, Jr., a JPL staff engineer working on the high-altitude rocket project, told MISSILES AND ROCKETS the experiment will seek to find out how the trailing-edge shape can be used to interpret the nature of the surface. Main interest is in whether the trailing edge indicates roughness or whether it relates to the dielectric features of the surface.

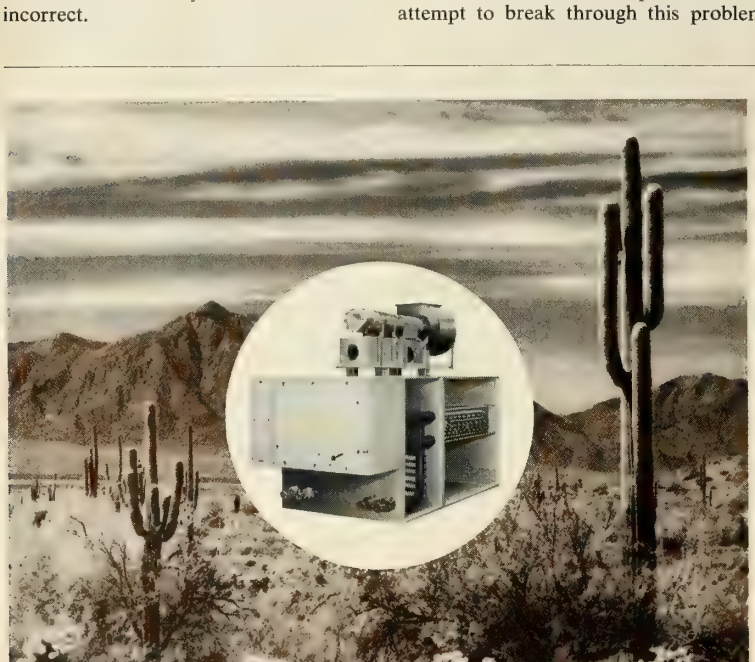
● **Why White Sands?**—White Sands has been selected because it is a typical dry desert landscape. An antenna system will be buried in the desert to find out how far the radar waves from the *Aerobee* penetrate. One of the questions facing radar astronomers is whether they are receiving reflections from the surfaces of the Moon and planets or from layers several meters below the surfaces.

Brown expects that an appreciable amount of power will penetrate the desert. Antennas located one wavelength, 10 wavelengths, and 30 wavelengths below the surface of the desert would probably be the best arrangement to measure this, but 30 ft. is likely to be a practical limit to the depth of antennas. All cables to these antennas will have to be shielded with absorbing material to prevent stray pick-up.

All vehicle aspects of the experiment are the responsibility of NASA's Goddard Space Flight Center, which provides the sustainer, recovery package, and attitude-control system. JPL will provide the radar, telemetry, ground installation, and a camera to take pictures of the surface.

Total payload weight is about 300 lb., with the science accounting for 135 lb. The radar has a nominal peak power of 90 kw, a pulse width of 10 microsec., and repetition rate of 150 pps.

● **Flight description**—Launch will occur between one and three hours after sunrise to ensure good definition in the photographs. The sustainer will burn out at an altitude of 27 miles, 54 seconds after launch, and the attitude-control system will start to turn the rocket over into a horizontal position.



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The Model MAF-90160 Air Conditioner shown above, for example, is typical of many basic units which can be used individually or as components of complete environmental control systems for military applications. Designed and developed by AAF for the advanced Minuteman weapon system, the MAF-90160 will withstand shock loads of 5 G's. It also features radio interference suppression and effective filtration of particles larger than 0.3 microns. Air circulation rate is 455 lb/min. Maximum cooling capacity is 166,700 Btu/hr from sea level to 7,000-ft altitude conditions.

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After 135 seconds, the maneuver is complete and the rocket has reached an altitude of 93 miles, continuing up on a ballistic trajectory. The data system is switched on at this time and continues until the recovery sequence is initiated.

A maximum altitude of 125 miles is expected. The flight will continue generating data until 400 seconds after launch, by which time the *Aerobee* will fall to 62.5 miles. At this altitude, the attitude-control system can no longer prevent weather cocking. The payload then separates and descends by parachute, landing some 1,100 seconds after launch. About 260 seconds of radar data should be obtained if all goes well.

The flight will be in a south-north direction, with impact some 50 miles downrange, west of Alamogordo, N.M. On the up-leg of the trajectory, the first pulse-width illumination area will cover normal desert terrain. As apogee is approached, the gypsum dunes of the White Sands National Monument will come into view. These will cover most of the illuminated area by the end of the data-taking sequence.

● **Transmission details**—A calabrator unit on the ground will act as a transponder during radar transmission from the *Aerobee*. On receipt of pulse from the radar on the *Aerobee*, it will transmit a pulse with a staircase calibration pattern delayed by 850 microsec, which will be picked up by the radar receiver on the *Aerobee*.

Right-hand circularly polarized waves will be transmitted from the *Aerobee;* both right-hand and left-hand circularly polarized returns will be received and recorded in the vehicle, using a receiver bandwidth of 1 mc. The antenna, produced by Rantec Corp., is a pair of crossed dipoles in a cup behind a radome looking out of the side of the rocket.

Receiver video will be stored, together with clock pulses, on a flight tape recorder weighing about three pounds. This uses 0.25-inch tape running at about 30 ips and has a bandwidth of about 200 kc.

Receiver video will also be telemetered to the ground for pre-detection recording on magnetic tape. Sequential pictures of the video output at the telemetry receivers will also be taken.

Chief problems in radar design have been in obtaining reliability and a data accuracy of ± 1 db. Special modulation circuits have been developed to overcome the problem.

The on-board radar transmitter makes use of a magnetron, which operates continuously through the six-minute flight. Receiver sensitivity is −135 db and it has a dynamic range of −135 to −75 db. The aim is to measure both echo shape and absolute amplitude to an accuracy of ± 1 db.

● **Digital analysis planned**—A detailed analysis of the echo data will be carried out using digital techniques to try to formulate an analytic relationship between the surface and its echo characteristics. Once the penetration effects are known from the buried antenna measurements, surface profile measurements will be made at the site to see how accurately surface data are predicted from echo characteristics.

The echo data will be played back at one-tenth record speed and digitized over 50 microsecond intervals (5 microsecond intervals real time) during the echo duration (about 350 microseconds real time). Using a digital computer, effects of the receiver transfer function, antenna pattern and geometry will be removed. First and second moments of the probability distribution will be computed, together with the correlation coefficient between the polarized and the cross-polarized echoes.

The reduced data will be compared with the physical, electrical and chemical characteristics of the soil at 10 sites spaced equally along the flight path and 10 sites spaced the same distance apart across the flight path under the apogee point. ■

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space electronics

Miniature Frequency Synthesizer Among Goals of Expanding Microwave Firm

PALO ALTO, CALIF.—In-house manufacture of semiconductor diodes is planned by Watkins-Johnson Co., a microwave firm that is currently expanding its facilities to increase its systems work here.

Diode manufacture will give the firm the capability to fabricate microwave "integrated circuits"—combining semiconductors and yttrium-iron-garnet devices in a single small package. One important application of these will be satellite electronic surveillance systems.

First circuit will probably be a frequency synthesizer with electrical tuning. This will give outputs of a few milliwatts from a one-cubic-inch package, and will be suitable for surveillance receivers. Included in the package will be a crystal-controlled transistor oscillator, diode multipliers, the YIG filter and its tuning coil.

Later developments could lead to inclusion of the mixer function within the package. "I think this technique can be extended without limit. It is a question of how far you want to go," says Dean A. Watkins, president of the firm. He added that the aim of integrated techniques was not primarily to facilitate mass production but to obtain better performance with significant size and weight reductions.

● **Initial application**—The integrated devices will be used chiefly in receiver systems operating from 1-25 gc, for electronic reconnaissance, surveillance and RFI work. This is a product area in which W-J has shown most rapid growth in the past year. A new generation of electrically-tunable receivers is being developed by a number of firms in the microwave business and W-J is not alone in its realization of the potential of microwave integrated circuits.

The attraction of the reconnaissance receiver market is that it is a steady business and promises to expand continuously. Even a disarmament treaty would have little effect on it, since the need to keep a check on the other side's electronic activities would remain. "We don't know how large this market is, but we feel that it is very large," says Watkins. "This company, I think, could grow a great deal, just in this particular market."

In fact, W-J's activity in the receiving systems market prevented it being hurt badly by the 30% overall drop in the microwave tube market. The company's total sales in 1964 just topped those of 1963, rising from $9,539,640 to $9,602,546.

● **Facility expanding**—To provide for anticipated growth in systems production, Watkins-Johnson is constructing a 50,000 sq. ft. new building at its main location.

W-J's move into semiconductor production is made easier by possession of equipment and facilities now used for fabricating gallium arsenide laser diodes. Production will be modest to begin with, and will start with varactor and step-recovery diodes.

The decision to produce in-house came partly from experience with YIG in-house production. W-J found that better performance (Q and line width) could be obtained with in-house materials than with those from outside suppliers. This gave a competitive advantage in microwave filter performance and led to the idea of pursuing the same policy in the microwave semi-conductor field. ■

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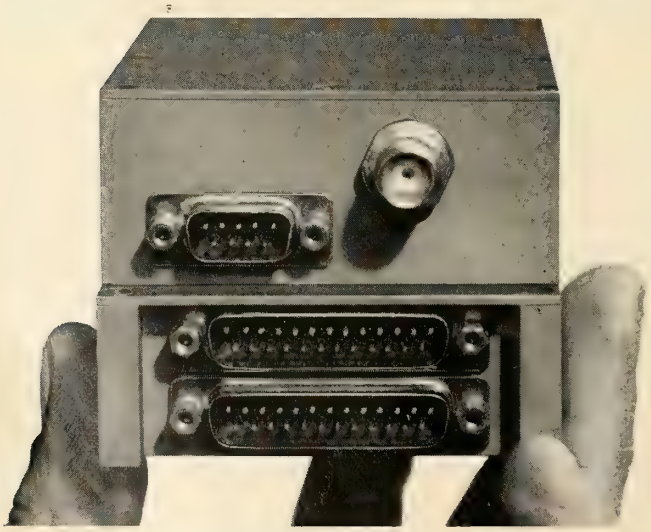


Circle No. 15 on Subscriber Service Card

space electronics

Spectrum Analyzer

The SIMORAMIC spectrum analyzer, designed to operate in real time and simultaneously over a frequency range of 1 to 200 cps without use of contiguous filters, is being marketed by Federal Scientific Corp.

The Model 4A-T uses special frequency conversion circuits which permit frequency coverage of the instrument to be positioned anywhere in the audio-frequency range, the firm says. Selectivity characteristic is independent of frequency; resolution is variable from 1 to 10 cps.

The unit is said to be 200 times faster than a conventional heterodyne analyzer of comparable frequency. All frequency analyses of the input signal is displayed on a CRT each second for 1-cps resolution or every 0-1 sec. for 10-cps resolution.

Circle No. 151 on Subscriber Service Card

Two-Stage Microwave Amp

Two pulsed-type Amplitron tubes have been developed by Raytheon Co.'s Microwave and Power Tube Div.

The QKS1243 produces peak power pulses of at least 500 kw with an input RF drive of 20 kw or more. Average power output is typically 700 watts with a 0.0014 duty cycle. Pulse duration is 2 microsecs. Typical gain is 14 db; efficiency is 52%.

The QKS1244 raises a 1-kw driver pulse to 25-kw peak power output. Gain is 14 db; average output power is typically 70 watts with a 0.0028 duty cycle. Pulse duration is 2.2 microsecs. The units are cooled by forced air and meet MIL-E-5400 environmental specifications.

A two-stage microwave amplifier with 27-db gain over a band of 9.5 to 9.7 gc can be formed by combining the two units with the Model IXH24 isolator. Typical efficiency is 50%.

Circle No. 152 on Subscriber Service Card

Resolver/Converter

A solid-state resolver/synchro-to-digital converter to link interfacing analog and digital systems has been developed by North Atlantic Industries.

The device functions by accepting three- or four-wire a-c analog data and computes the equivalent shaft angle, which is then expressed digitally in decimal or binary form. According to the firm, the up-dating period for full-scale input is a fraction of a second, accuracy exceeds 10 seconds of arc and any line-to-line voltage from 11.8 to 115v. is accepted.

Circle No. 153 on Subscriber Service Card

New Product of the Week:

Radiometer

Yellow Springs Instrument Co. is marketing the Model 65 radiometer, developed in conjunction with Kettering Research Laboratories.

The device is a wavelength-independent, direct-reading instrument which utilizes a small thermistor bolometer, capable of making readings in areas inaccessible to standard thermopiles and photovoltaic or photoresistive sensors, the firm says.

The unit reads directly in ergs/cm²-sec. and in milliwatts/cm². It covers a range of 2.5 x 10^3 to 2.5 x 10^6 ergs/cm²-sec. (0.25 to 250 milliwatts/cm²) in seven ranges of full-scale sensitivity. Accuracy is to ±5%. The instrument has balance offset for up to 1.2 x 10^5 ergs/cm²-sec. ambient radiation levels. It is equipped with an unmodified probe usable from 0.25 to 3.3 microns.

Circle No. 154 on Subscriber Service Card

Frequency Generator

A crystal-controlled, solid-state radio frequency generator, the Model 1102, is being marketed by EDP Corp.

The transmitter simulator provides incremental frequencies in the VHF (240 to 260 mc), telemetry bands and the UHF (400 to 485 mc) tracking bands. Power output of unmodulated frequencies is continuously variable to a maximum of 10 mw. The unit is equipped to make VSWR measurements.

The device contains three crystal-controlled oscillators, each containing from 7 to 23 preselected crystals. A dual-scale panel meter reads directly in output power (up to 10 mw) when a 50-ohm load is applied. VSWR is 1:1 to ± 5:1 when a mismatched load is applied.

Circle No. 155 on Subscriber Service Card

Miniature Freezer

A miniature freezer, utilizing the electronic cooling principle of thermoelectrics, has been developed by Schoeffel Instrument Co.

The Model TEC-5 Mini-Freezer is capable of attaining temperatures of —15°C within minutes, developers say. The unit employs a thermocouple module capable of removing approximately 5 watts of heat from the container. The cooling chamber is designed to accept either liquids or solids of heat-labile materials directly.

The inside container measures 1.5 in. in diameter and 3 in. deep. No coolant is necessary. It is directly operated on 115v, 60 cps, 18 watts.

Circle No. 156 on Subscriber Service Card

Impedance Bridge

The Model 292 universal impedance measuring system has been developed by Electro Scientific Industries, Inc., for precise measurements of resistance, conductance, capacitance and inductance. For capacitors and inductors, it also measures the dissipation factor (D) and storage factor (Q).

Design permits a conservative accuracy rating of ±0.05% for resistance and conductance, ±0.01% for inductance and capacitance, developers say. Comparative five-figure measurements can be made using the 120,005 divisions of dial resolution provided by the decade dials. Terminals are provided so that ranges may be extended and special circuit connections can be made.

Circle No. 157 on Subscriber Service Card

Attenuator Set

A graded set of coaxial attenuators, covering a frequency range from dc to 10 gc, is being marketed by Stoddart Electro Systems Div. of Tamar Electronics, Inc.

The Model SA-1 set provides 50-ohm standard references at 3, 6, and 10 and 20 db over the entire range. The set contains four attenuators to cover the dc to 3-gc range and four covering the 3 to 10-gc range. Maximum insertion temperature coefficient of insertion loss is 0.0003 db/db/°C. Maximum power sensitivity of insertion loss from 1 mw to 1 w is 0.05 db/db.

Circle No. 158 on Subscriber Service Card

Variable Attenuators

A series of broadband variable attenuators utilizing a patented Ridged Coaxial Line is available from Merrimac Research and Development, Inc.

The series AU units feature "zero loss"—typically less than 0.5 db at 4 gc. They are rated at 4 watts with a VSWR less than 1.5:1. Standard models are designed for 50-ohm impedance.

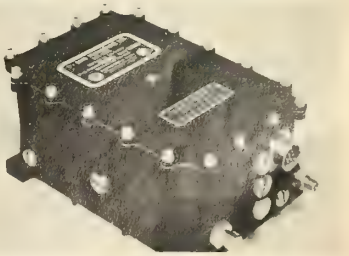
Typical units of the line are Model AU-15A (2-8 gc), Model AU-25A (1-8 gc) and Model AU-45A (0.5-8 gc). The three units can be used in derated situations to 1-12 gc, 0.5-12 gc and 0.2-12 gc respectively. Attenuation ranges are in excess of 15, 30 and 60 db respectively from 4 to 8 gc for the models.

Circle No. 159 on Subscriber Service Card

Radar Transponder

A microminiaturized superheterodyne C-band transponder for use with precision tracking radars is available from Military Electronics Div. of Motorola, Inc.

The device, designated SST-135C, was designed and built to NASA specifications. Characteristics include: power output, 700 watts; input power, 24 to



30v dc; power drain, 0.9 amp at 1,000 pps, 0.7 amp at standby; tuning range 5,400 to 5,900 mc; sensitivity, —65 dbm under all specified environments; recovery time, 50 μsecs, maximum.

Circle No. 160 on Subscriber Service Card

Distortion Analyzer

Hewlett-Packard Co. has developed two total harmonic distortion analyzers with 0.1% full-scale display at maximum sensitivity. The units measure distortion down to 0.03% at any frequency from 5 cps to 600 kc and measure noise and hum levels as low as 50 mv.

The Models 331A and 332A have solid-state tunable circuits which reject fundamentals by more than 80 db while passing harmonics as high as 3 mc. Model 332A features an AM detector for distortion analysis of modulation envelopes on carriers as high as 65 mc.

Input signals as low as 0.3v ac RMS may be analyzed on all scales, including the 0.1% range. The input attenuator accommodates the meter to measure signals up to 300v. Input impedance is 1 megohm shunted by less than 60 pf.

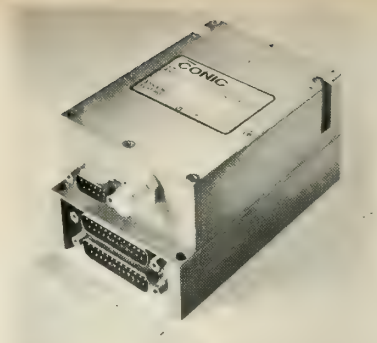
The instrument may also be used as a high-impedance ac voltmeter, flat from 5 cps to 3 mc, with 13 ranges from 300 μv to 300v full-scale.

Circle No. 161 on Subscriber Service Card

Solid-State Receivers

Conic Corp. is marketing a line of solid-state receivers, designed to meet severe missile requirements.

The units provide ±0.005% tuning accuracy and local oscillator stability. Noise figures are held at 4 db maximum. Operational bandwidths range from −3 db = 100 kc, −60 db = 300 kc to −3 db = 300 kc, −60 db = 900 kc. Command receivers offer up to seven relay channels operating in IRIG channels 1 through 20. All models provide 80-db image and spurious response rejection and 2-v RMS maximum RF input.



Circle No. 162 on Subscriber Service Card

Single Capstan Transport

A single capstan digital magnetic tape transport, capable of bidirectional tape speeds of 75 and 112.5 ips at 800 bpi with no program restrictions, has been developed by Potter Instrument Co., Inc.

The Model SC-1060 is 7- or 9-channel compatible and can be adapted to all major computer formats. A tape drive design utilizes the signal capstan to pass the tape through a low friction tape path. Tape is threaded directly from the supply reel over the read/write head to the take-up reel. From this point, loading is accomplished automatically by push button. The oxide side of the tape touches no surface except the read/write head, greatly increasing tape life and data reliability, the firm says.

Specifications include a start time and stop time of 3 millisecs. and rewind of less than 90 seconds for 2,400 ft.

Circle No. 163 on Subscriber Service Card

PCM Signal Simulator

A pulse-code-modulation signal simulator for ground station monitoring of telemetered signals is being marketed by Roback Corp.

The unit is a complete PCM test lab including a built-in bit-by-bit comparator with panel-controlled signal delay. It generates all commonly used PCM codes (RZ, NRZ-C, NRZ-S, NRZ-M, split phase) in either polarity at rates from 1 to 1,000,000 bits per second. Signals can also be generated in bi-polar form.

The Model 200, one of several models available, can be programmed to provide up to six words ranging in length from 2 to 34 bits with data content controlled by front-panel toggle switches. Format is controlled by a removable preprogrammed patch panel. Frame length may vary from 1 to 2,048 words; subframe length, from 1 to 256 frames. An additional feature is a self-contained, 6-pole Bessel filter, which can be used to bank limit noise, signal or both.

Circle No. 164 on Subscriber Service Card

X-Ray Electron Beam Source

A two-million-volt mobile X-ray machine and an electron beam tube providing high-intensity electrons, X-rays or neutrons from a single source have been introduced by Field Emission Corp.

The unit is capable of penetrating up to 6 inches of steel or 14 inches of aluminum, providing high-resolution radiographs of high-speed events and large objects, developers said. X-ray pulse length is 30 nanosecs. for "stop-motion" radiographs at high velocities.

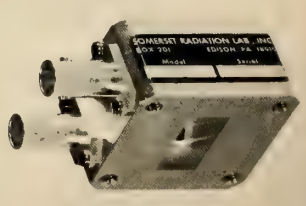
For radiation effect studies, dose per pulse available with the external beam is 5,000,000 rads for electrons, 4,000 rads for X-rays. The machine is compatible with the company's other Fexitron instruments so that X-ray sources at 105, 150, 300, 600 and 2,000 kv can be operated in one system. This allows cineradiographs to be taken at frame rates up to a million per second, with X-ray source changed to or matched with each frame.

Circle No. 165 on Subscriber Service Card

Digital Phase Shifter

Somerset Radiation Laboratory, Inc., is marketing the Model X700 two-step, X-band digital phase shifter. The electronically controlled, crystal-diode unit features an insertion length of 1 in. and insertion loss of 0.3 db maximum. Peak power capability is 1,000 watts.

Other specifications include a nominal frequency range of 8.2 to 12.4 gc and 0.001 duty cycle with 1.0-microsec pulse. Average power is 10 watts. As a phase shifter at 9.3 gc, VSWR is 1.3:1 maximum. Typical operation as a single-cavity filter provides 150 mc between peaks in the region of 9.3 gc. Rejected peak is 15 db down from desired peak.

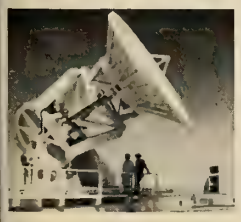


Circle No. 166 on Subscriber Service Card

Circle No. 9 on Subscriber Service Card

PRECISELY! A GREAT NEW ANTENNA FACILITY AT ROHR

Now in operation, this massive radial arm mill is capable of machining 50-foot diameter workpieces while holding a tolerance of .002 rms. This new Rohr-designed mill was patterned from the original Rohr boring machine used to mill the famous 15-foot radio telescope for Aerospace Corporation . . . the most precise of its kind ever built, with reflector surface accuracy of .0018 rms achieved over the required .004 rms. The new mill was especially designed for machining a 36-foot diameter solid face reflector for the National Radio Astronomy Observatory. Future plans call for converting the machine into a 50-foot boring mill with seven motions, four numerically controlled. This is a prime example of Rohr's special performance in meeting antenna customer requirements . . . and why Rohr consistently maintains a large antenna sales backlog.

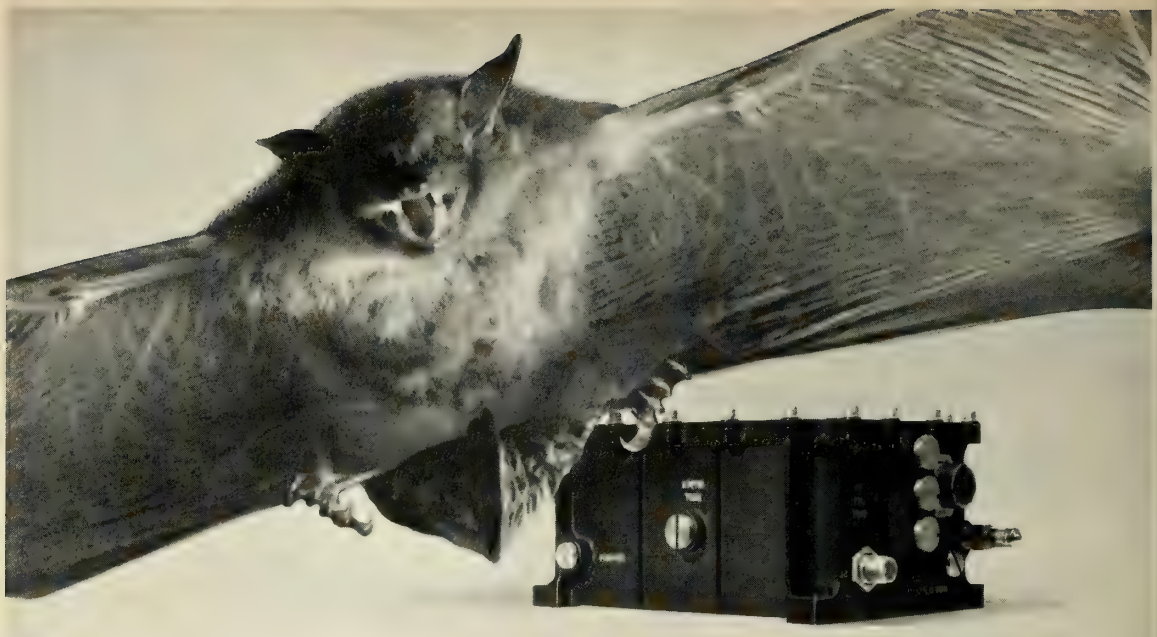


For complete information regarding Rohr's antenna design and manufacturing capabilities, please write Marketing Manager, Rohr Corporation, Antenna Division, Dept. 47, Chula Vista, California.

ANTENNA DIVISION

ROHR CORPORATION

Circle No. 1 on Subscriber Service Card



Bats will never replace our radar transponders!

NATURE-LOVERS are often quick to point out that bats have the most efficient radar-type system known. Man, they say, can't approach it. With their tiny echolocation systems, bats emit high-frequency vocal signals that can detect an insect up to seven feet away...even in total darkness. The bat can lock on to a course that quickly culminates in impact and consumption.

This, admittedly, is remarkable. But Motorola radar transponders are required to send and receive reliable signals over vast distances—so they have been selected (in preference to bats...and even some very good man-made units) for use on major aerospace programs, such as Saturn... Pershing...Centaur...Apollo...Asset...Hounddog...X-15...Gemini...Agena...Improved Delta to name a few. They are also range-qualified at WSMR, AMR, Eglin, and Edwards AFB.

Some of our off-the-shelf transponders on current programs include:

SST-135C (shown above): a new, general-purpose, solid-state, microminiaturized superheterodyne C-band transponder designed to full NASA quality and workmanship specs. High-component-density welded modules meet performance requirements for solid or liquid fuel rockets, missiles, and spacecraft. Qualified for Saturn, the SST-135C has 700 watts output, —65 dbm sensitivity, 0.05 μsec delay stability, weighs 5.5 pounds.

AN/DPN-66: 800 watts output, —70 dbm sensitivity, 0.05 μsec delay stability, 0.75 amp standby power drain.

SST-131: solid-state, microminiature, superheterodyne C-band transponder. 400 watts output, 3 pounds max.

SST-133X: general-purpose X-band transponder for use on drones, aircraft, and high-thrust launch vehicles. Volume: 44 cubic inches. Can be interchanged with our SST-131 C-band unit without modifying missile mounting configuration.

We can modify existing equipment, or produce new custom designs for you in short order. Incidentally, we lead the field in CW transponders, too. For example, the units which have so faithfully responded on Mariner and Ranger space missions were built by Motorola, in cooperation with NASA/JPL.

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For descriptive literature, check and mail to Dept. 1007, Motorola Military Electronics Div., 8201 E. McDowell Rd., Scottsdale, Arizona

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- ☐ Nomograms—A guide to Transponder Selection
- ☐ Radar Systems Capabilities Brochure, and pamphlet, "Bits about Bats"

Circle No. 11 on Subscriber Service Card

New Activities

United Aircraft Corp. has given the Vector department of its Norden Div. division status and plans to construct a new 100,000-sq.-ft. building for the division in Trevose, Pa. Vector designs and makes telemetry systems and components. . . . *Purdue University, Lafayette, Ind., has established The Institute for Advanced Interdisciplinary Engineering Studies, a facility for investigating problems requiring a combination of engineering techniques for their solution.* . . . C-E-I-R, Inc., Arlington, Va., has formed an Applied Research and Management Sciences Div. to consolidate the firm's top U.S. scientific and professional personnel into a single national organization. Many of C-E-I-R's scientists will continue to operate from the firm's five domestic computer centers and three field offices, but regional lines have been erased to improve consulting and problem solving services. Seven departments—Information Processing Systems, Operations Research, Statistical Sciences, Economics/Econometrics, Scientific/Engineering Applications, Mathematical Programming and Network Planning/Scheduling—are included in the new division. . . . *SDS Data Systems, Los Angeles, has formed a new Systems Dept. to handle increased volume of the firm's computer systems business and to centralize several functions, including systems design, systems engineering and programming, and simulation systems. SDS makes general purpose digital computers for space, military, scientific, and industrial applications.* . . . General Motors' Allison Div. has assumed jurisdiction of GM defense contract responsibilities presently handled by the Cadillac Motor Car Div. and headquartered at the Cleveland Army-Tank Automotive Plant.

Mergers and Acquisitions

URS Corp., Burlingame, Calif., has acquired PARMAC Machine Accounting Service of Tucson, Ariz., and has made plans to develop the company into a computer service center to provide systems design, programming, and data processing services for business, industry and government. The new facility will be known as the Tucson Data Center of URS Corp. . . . *The TRIMPOT division of Bourns, Inc., Riverside, Calif., has signed a licensing agreement with Douglas Aircraft Co. to produce and sell a new solid-state computing device trademarked Quadratron. Bourns initially will make two types: the model 4100A-1-010, a 10-volt unit; and the model 4100A-1-100, 100-volt unit.*

Facility Expansions

The LEL Div. of Varian Associates in Copiague, N.Y., has acquired a 10,000-sq.-ft. building adjacent to its present plant. LEL develops and manufactures microwave RF and IF equipment, including mixers, strip transmission line components, amplifiers, and laboratory receivers. . . . *Sylvania Electric Products, Inc., has built an ultra-quiet chamber in Buffalo, N.Y., for testing aerospace antennas in the simulated communications environment of space. The facility comprises 18,000 cu. ft. of virtually echoless and interference-free space.* . . . Space-Lok, Inc., Van Nuys, Calif., producers of quick-release pins, has moved to larger plant facilities in Burbank, Calif. The new plant affords 17,500 sq. ft. of production and inventory space, twice that formerly available. . . . *United Aircraft Corp.'s Pratt & Whitney Aircraft Div. has announced plans to add 700,000 sq. ft. of floor space to its East Hartford, Conn., facilities. The new area is scheduled for occupancy in mid-1966 and will include a materials center and an office building.*

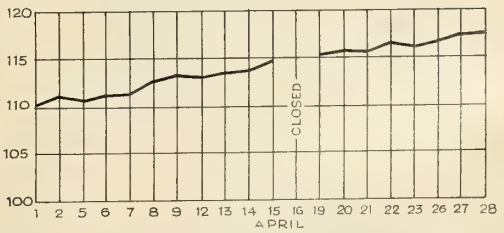
California Space Museum Gains Support

California state assembly speaker Jesse M. Unruh has introduced legislation to speed up establishment of a permanent space museum to be located in Los Angeles. Unruh's bill would exempt from state taxes some $1 million in revenue bonds issued to finance exhibits in the California Space Museum. Director Dr. William F. Fitzgerald of the museum, which has temporary exhibits in the Los Angeles Armory Building, estimates that passage of the bill would make possible completion of the museum within two years.

Missile/Space Backlog Off 2%

Orders for missile and space vehicle systems and parts, including propulsion units, were valued at $4.556 billion as of Dec. 31, 1964, representing a decrease of 2% from the $4.646-billion backlog at the end of 1963, according to figures just released by the Bureau of the Census. The figures were compiled from Census Form M37D, "Quarterly Report of Backlog: Complete Aircraft, Space Vehicles, Missiles and Selected Parts," received from 60 companies. Net new orders for 1964 for prime contractors amounted to $5.793 billion; for subcontractors, $498 million. Comparable for 1963 were: $7.237 billion and $582 million, respectively.

Missile/Space Stock Index



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
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In less than one second, CEC's new TCLD pinpoints leak locations—finds leaks of almost any gas or vapor. Headphones signal leak locations. A meter measures leaks as small as 1×10^{-5} atm/cc/second.

Designed for workmen to use, this belt-mounted portable instrument is simple to operate, rugged, accurate—and weighs less than seven pounds.

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Circle No. 12 on Subscriber Service Card

contracts

AIR FORCE

$16,000,000—**Martin Co.,** Denver Div., Denver, for development, production and launch of a third version of the *Titan III-X* launch vehicle.

$4,882,500—**Avco-Everett Corp.,** Research Laboratory, Everett, Mass., to measure electromagnetic emissions and reflections of re-entry vehicles and to process and analyze resulting data.

$3,900,000—**General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., New York City, for the production of instructions and specifications on the operation and maintenance of a ground electronics system to regulate the monitoring, targeting and firing of *Minuteman* missiles.

$3,565,100—**Ryan Aeronautical Corp.,** San Diego, Calif., for target drones.

$2,249,643—**Martin Co.,** Baltimore, to produce ground handling equipment for the *Bullpup B* air-to-surface missile.

$2,422,000—**North American Aviation, Inc.,** Canoga Park, Calif., for continued production of *Atlas* propulsion systems.

$2,300,000—**Thiokol Chemical Corp.,** Bristol, Pa., for continued production of Stage 1 rocket motors for *Minuteman.*

$1,500,000—**System Development Corp.,** Santa Monica, Calif., for continued work on an unspecified satellite-control system.

$1,472,000—**Dynamics Corp. of America,** Radio Engineering Laboratories, Long Island City, N.Y., for tropospheric scatter communications terminals for use in the Mediterranean Communications System.

ARMY

$3,199,500—**Akwa-Downey Construction Co.** and **Radio Communications Co., Inc.,** Milwaukee, to furnish the cable and install it in the Vehicle Assembly Building and the Launch Control Center.

$1,102,000—**Thompson Ramo Wooldridge, Inc.,** Redondo Beach, Calif., for continued work on a classified project.

$1,000,000—**Electronic Modules Corp.,** Timonium, Md., for work on a classified electronics project.

NAVY

$4,500,000—**Westinghouse Electric Corp.,** Sunnyvale, Calif., for development work on submarine-launched ballistic missiles.

$3,874,206—**Collins Radio Co.,** Dallas, for communications sets and data terminal sets.

$2,526,910—**General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., New York City, for production of computer systems.

$2,124,434—**Sperry Rand Corp.,** Bethpage, N.Y., for the work on an inertial navigation system for *Polaris* submarines.

$1,213,250—**Bendix Corp.,** York, Pa., for design and development work on *Phoenix* missile.

NASA

$1,568,831—**Radio Corp. of America,** Aerospace Systems Div., Van Nuys, Calif., for the *Saturn* 110 computer system.

$804,000—**G. T. Schejeldahl Co.,** Northfield, Minn., for fabrication of six inflatable 100-ft.-dia, space structures to be used in the National Geodetic Satellite Program.

$483,930—**Perkin-Elmer Corp.,** Norwalk, Conn., for carbon dioxide measurement systems designed for use in the manned *Apollo* vehicles and for associated ground support systems.

$318,300—**Hayes International Corp.,** Huntsville, Ala., for research and development engineering services and other related services.

$285,064—**United Engineers and Constructors, Inc.,** Jackson and Moreland Div., Boston, for review, analysis and development of planning data for the laboratories for the Electronics Research Center.

$116,600—**Battelle Memorial Institute,** Columbus, Ohio, for an advanced thermoelectric component development program.

INDUSTRY

$461,700—**Milgo Electronic Corp.,** Miami, Fla., from **General Electric Corp.,** Radio Guidance Operation, Syracuse, N.Y., for a data transmission, processing and display subsystem at Wallops Island, Va.

$350,000—**Beckman Instruments, Inc.,** Richmond, Calif., from **Douglas Aircraft Co., Inc.,** Santa Monica, Calif., for a hybrid analog-digital computer to be used in the development and test of advanced rocket engine guidance and control systems.

$300,000—**Douglas Aircraft Co., Inc.,** Santa Monica, Calif., from **Morrison-Knudsen-Perini-Hardeman,** Merritt Island, Fla., to provide the super lightweight aircomb for a 5,000-ton *Apollo/Saturn V* mobile service structure.

$107,900—**Hayes International Corp.,** Birmingham, Ala., from **Boeing Co.,** Seattle, for support hardware for *Saturn* S-IC stage.

NASA'S NEW

ELECTRONICS RESEARCH CENTER

A SPECIAL REPORT...

...to be published in MISSILES AND ROCKETS May 31, 1965 issue. The new center, although just entering the construction phase, has already issued RFP's to industry for electronics research contracts. The center which will eventually direct 50% of NASA's electronics research, has a FY '66 budget which already has reached $22 million, and by 1969 should reach $100 million.

More important, the Electronics Research Center will be in the forefront of NASA's drive to achieve the state-of-the-art advances in electronic systems and components required to carry out the sophisticated space missions planned in the late sixties and through the next two decades.

This report will provide in-depth analyses of Electronics Research Center's plans and programs, procurement policies, responsibility in electronic research and the construction schedule, costs and equipment for the individual laboratories.

For companies marketing to NASA, this report offers a unique opportunity to reach the heart of the buying influences. Plan now to capitalize on this outstanding advertising opportunity.

Bonus Circulation: This issue of MISSILES AND ROCKETS will be delivered to every engineer, every designer, every scientist, and every management man at the Electronics Research Center. Copies will be made available to other Electronic Centers of NASA.

PUBLISHED: MAY 31 **ADVERTISING CLOSES: MAY 17**

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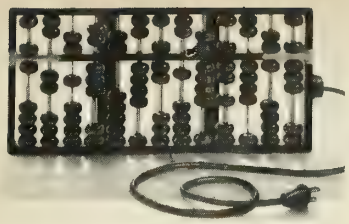

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DESIGN computer systems and evaluate equipment for information retrieval, graphic processing and real-time missile component testing.

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DEVELOP real-time data systems for commercial applications such as source data acquisition, updating, retrieval and administrative control systems.

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names in the news

RAY

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MIRABITO

Julian H. Ray: Named chairman of the board of directors of Washington Technological Associates, Inc. He is one of the founders of the firm. **Presson S. Shane** has been named president and chief executive officer, succeeding Ray.

Grier D. Patterson: Elected a director of General Telephone and Electronics Corp. He is with the law firm of Winston, Strawn, Smith and Patterson in Chicago.

David Gerstein: Appointed president of the data and controls division of Lear Siegler, Inc. He succeeds **Morris Sobin,** who resigned.

Paul S. Mirabito: Promoted to group vice president of the Defense and Space Group of Burroughs Corp.

Joseph E. Robbins: Elected president of Spacerays, Inc., manufacturer of electro-optical systems and components. Also elected was **David C. Gordon,** chairman of the board.

Clifford J. Helms: Elected a vice president of Data Products Corp. He is director of advanced development for the Line/Printer Div. **Irving L. Wieselman,** director of advanced Discfile products, was elected a vice president also.

Vice Adm. William F. Raborn (USN Ret.): To replace **John A. McCone** as head of the Central Intelligence Agency. He has been Aerojet-General vice president-project management and was formerly in charge of developing the Navy's *Polaris* program.

Dr. Frank E. Bothwell: Appointed director of the Center for Naval Analyses where he is also chief scientist. **Edwin A. Speakman,** former vice president of missile range programs at Radio Corp. of America's Service Co., was appointed to assist Dr. Bothwell.

Vincent F. Volpe: Promoted to director of mechanical engineering research at the Illinois Institute of Technology's Research Institute. **William E. Reynolds** has been named to assist him.

Hale Montgomery: Joined the information Div. of Comsat Corp. as general information officer. He was formerly with United Press International as a reporter.

Robert W. Miller: Joined United Research, Inc., as vice president in charge o the company's Defense and Space System Management Group. He was formerly wit Raytheon Co.

Walter V. Tyminski: Named chairma of the board of Intelectron Corp. He i president of Belock Instrument Corp which recently purchased 50% interest i Intelectron.

Ken Ellington: Named manager of th Aerospace Industries Assn.'s western office He is vice president of Republic Aviatio Corp.

Robert P. Bosley: Appointed vice presi dent of quality control at Litton Industries **Norman Pell** was also appointed a vic president, and will be in charge of market ing operations.

Melvin M. May: Elected president o Simulation Systems, Inc., the newly-forme subsidiary of Computer Systems, Inc **Robert M. Griggs** was elected vice presi dent, and **Richard C. Allen** is vice presi dent-engineering. **Robert Haskins,** presiden of Computer Systems, will serve as boar chairman.

E. F. Buehring: Elected president o the National AeroSpace Services Assn. He is president of Ling-Temco-Vought's Elec trosystems, Inc. Other officers elected were **Duane O. Wood,** president of Lockheed Aircraft Service Co., as vice president, an **Harry W. Baer, Jr.** of Washington, D.C. as treasurer.

Angus Scott: Designated to fill the newly-created position of vice president in charge of operations for the International Rectifier Corp.

Frank Schwoerer: Promoted to technical director of Nuclear Utility Services Inc., consultant-engineering corporation He was previously manager of engineering

Robert A. Aspinwall: Elected treasurer of United Aircraft Corp. He succeeds **Carroll L. Gault,** who is retiring after three decades in the position.

A. C. Martinsen: Elected president of Catalytic Construction of Canada, Ltd. He was formerly executive vice president and general manager of the firm.

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—when and where—

MAY

19th Annual Technical Conference of the American Society for Quality Control, Biltmore Hotel, Los Angeles, May 3-5.

Symposium on Numerical Solution of Partial Differential Equations, sponsored by Air Firce Office of Scientific Research, Office of Naval Research and University of Maryland, University of Maryland, College Park, May 3-7.

Post-Apollo Missions, sponsored by the American Astronautical Society, Conrad Hilton Hotel, Chicago, May 4-6.

Seminar on Systems and Subsystems Management, sponsored by the National Defense Education Institute, New York City, May 4-6.

1965 Microwave Theory and Techniques Symposium, sponsored by the Institute of Electrical and Electronics Engineers (IEEE), Jack Tar Harrison Hotel, Clearwater, Fla., May 5-7.

Spring Meeting of the Society for Experimental Stress Analysis, Cosmopolitan Hotel, Denver, May 5-7.

1965 Electronic Components Conference, sponsored by IEEE and the Electronic Industries Assn., Marriott Twin Bridges Motor Hotel, Washington, D.C., May 5-7.

Underwater Technology Conference, sponsored by the American Society of Mechanical Engineers, Mohican Hotel, New London, Conn., May 5-7.

27th National Meeting of the Operations Research Society of America, Statler Hilton Hotel, Boston, May 6-7.

Sixth National Symposium on Human Factors in Electronics, sponsored by IEEE, Sheraton Hitel, Boston, May 6-8.

Conference on Ultrapurification of Solid-State Electronics Materials, sponsored by Air Force Cambridge Research Laboratories and the New York Academy of Sciences, New York City, May 8-10.

1965 Spring Meeting of the Electrochemical Society, Sheraton-Palace Hotel, San Francisco, May 9-13.

Symposium on Passive Gravity-Gradient Stabilization, sponsored by NASA's Ames Research Center, Moffett Field, Calif., May 10-11.

International Conference and Exhibition on Nuclear Reactors and Radioisotopes, sponsored by the Canadian Nuclear Assn., Quebec, P.Q., May 10-12.

National Aerospace Electronics Conference, sponsored by IEEE and the American Institute of Aeronautics and Astronautics, Dayton, Ohio, May 10-12.

Symposium on Pulsed Neutron Research, sponsored by the International Atomic Energy Agency, Karlsruhe, Germany, May 10-13.

Annual Meeting of Shareholders of the Communications Satellite Corp., Shoreham Hotel, Washington, D.C., May 11.

Purchasing and Subcontracting Seminar, sponsored by the National Defense Education Institute, New York City, May 11-13.

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The European Myth

DISCUSSIONS between U.S. and European delegates to last week's Eurospace meeting in Philadelphia brought forward several illuminating facts about the European space effort.

The myth that there is a substantial market for U.S. space hardware in Europe was quickly dispelled. The Europeans are eagerly seeking means to acquire U.S. technical know-how and systems management capability without buying hardware. Unfortunately, none of the visitors managed to explain how this would profit the United States.

This was recognized in a blunt statement by Lockheed vice president Elmer P. Wheaton:

"As we see the situation, the real reason today for joint U.S.-European industrial cooperation is to facilitate the acquisition by Europe of the technical capability the United States has been fortunate enough to develop. If we objectively appraise the existing circumstances, we all recognize that U.S. cooperation will often simply strengthen the European ability to compete more effectively with U.S. firms. With these facts in mind, it is obvious that the purchase of U.S. hardware does not best fulfill Europe's aims."

Mr. Wheaton pointed out that, similarly, financial investment by U.S. firms in European companies fails to adequately enhance Europe's space competence. He suggested that employment of U.S. firms to work cooperatively in joint U.S.-European industrial space efforts offers the most logical means for transfer of technical and management know-how.

The Lockheed official suggested a number of scientific programs in which such joint industrial participation might be apt.

There are, however, several major stumbling blocks to even this type of cooperation. The willingness of European taxpayers to support any space project which is not totally European is a big question mark.

As Lord Caldecote, managing director of the guided weapons division of British Aircraft Corp., put it: "I cannot believe European taxpayers will be prepared to put forward money for programs on which American firms are prime contractors." This sentiment was echoed by many of the delegates.

A second difficulty lies in the abject failure of Eurospace itself to decide what programs it should undertake. In Philadelphia, the organization appeared to be suffering from a severe case of schizophrenia.

Proposals ranged from such ambitious manned undertakings as *Aerospace Transporter* to more modest steps forward in which small unmanned scientific satellites would be boosted by the ELDO launchers already under development.

Those pushing for *Aerospace Transporter* feel that some such dramatic manned project is necessary to attract the widespread public support required to make Europe a third major power in space. This view completely overlooks the folly of attempting an overly ambitious program on a base of very limited knowledge.

On the other hand, those pressing for a more modest beginning are faced with the undeniable fact that such projects do not have the glamor to gain the public and political enthusiasm necessary to obtain funding. Even the small programs are expensive by European standards.

There is further difficulty because there is no such political entity as Europe. National pride, prestige and security have played a large role in the decisions of the Soviet Union and the United States to support vast, expensive space programs. No such motivating factor exists in Europe.

To the contrary, national ambitions already are having a divisive effect in Eurospace. Aside from such internationally minded participants as Eurospace President Jean Delorme himself, the French, plainly, are more interested in their own space plans than in those of a European consortium. Other countries, such as Germany, see the international approach as being a faster path to the knowledge they seek.

THE MOST HOPEFUL route to European space collaboration probably lies in the proposals put forward for navigation, meteorological and television satellites. It is true that the nations of Europe have collaborated successfully in such areas as the European Coal and Steel Community and the Common Market. But this success has occurred only when it was clearly to the profit of the individual nations concerned. Benefits of scientific satellites are not so clear.

If it can be shown that an all-European commercial satellite program holds promise of a profitable return to those countries involved, then a major step will have been taken toward an on-going Eurospace program. The management structure to direct it will easily evolve.

But until Eurospace itself has looked frankly at these problems and made its decision on what projects to undertake, it is useless to speak of cooperation from the U.S. The question must be, cooperation on what?

Several of the European delegates expressed awe at the facilities of General Electric's space center at Valley Forge. We suspect that by the time they have completed their tour of many more U.S. plants, the Goddard Space Flight Center and the Merritt Island Launch Area at Cape Kennedy, the delegates will return home even more overwhelmed at the fantastic cost of building just the ground facilities to support a large space program.

This may have a moderating effect on the Eurospace members who have advocated leaping immediately into an unrealistic manned program. The visit will indeed have been beneficial if it turns the organization onto a more sensible course. But until that is accomplished, there is little to be found in talk of U.S.-European cooperation in space.

William J. Coughlin

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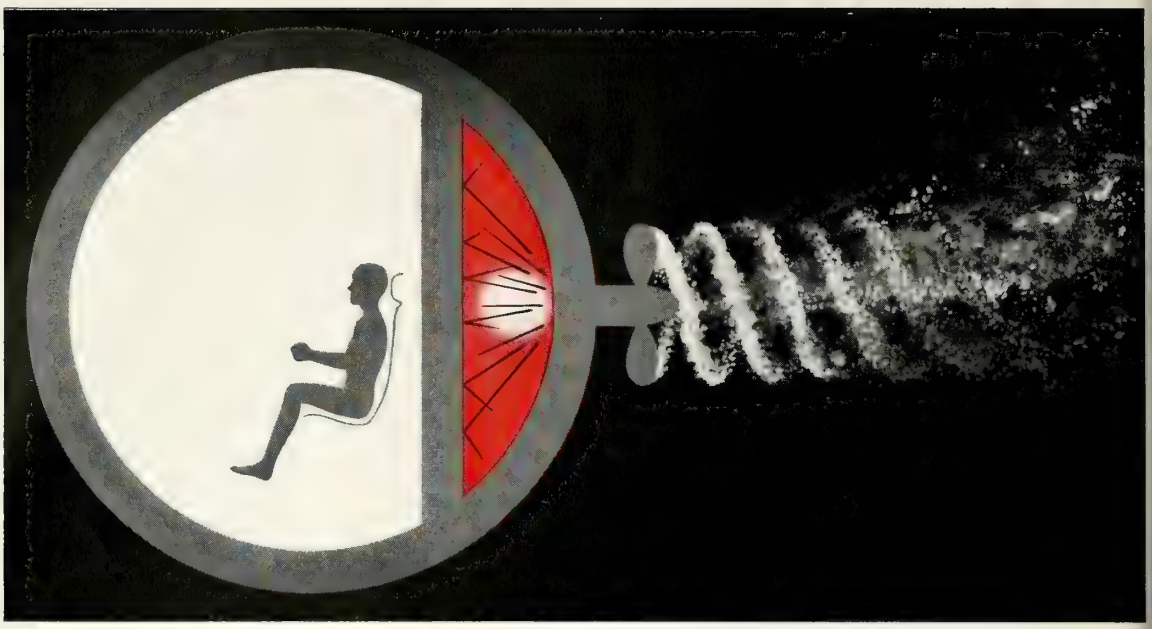

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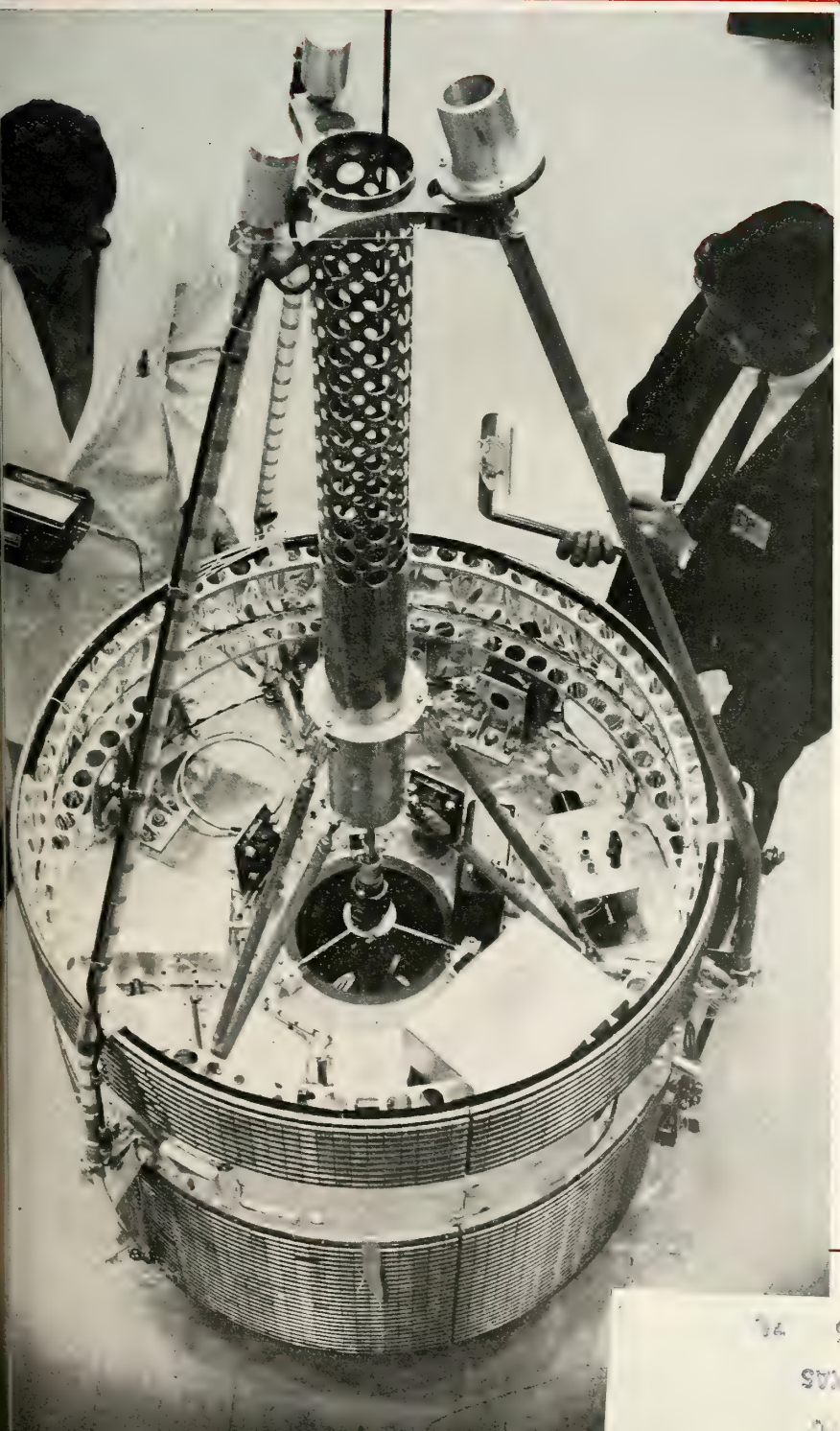

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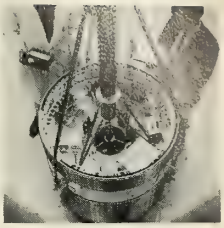

THE COVER

Pioneer interplanetary spacecraft built for NASA by TRW Space Technology Laboratories undergoes tests. Pioneer is to be launched late this year. It will carry eight solar-physics experiments in an orbit paralelling that of Earth, but will lead this planet by 40-60 million miles.

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letters

SNAP 10A Lifetime

To the Editor:

Your April 12 issue summarizing the excellent results of our recent SNAP 10A orbital flight contained two somewhat misleading statements bearing on the same issue.

One indicated that the "useful operation of the system is restricted by the lifetime of the *Agena* spacecraft's telemetry system, which is of standard design so far as radiation hardness is concerned."

The *Agena* "standard design" referred to in that statement applies only to one of the telemetry links aboard. Its usefulness, as that of the *Agena* guidance system, was limited to launch, orbit injection and the first few days of orbital life.

All other electronic equipments, including the Lockheed Primary and Secondary payload PAM/FM/FM telemetry links, were specifically designed for this mission. These are radiation "hardened" and tested designs and are expected to perform for at least the useful life of the reactor. Preflight tests and actual flight data collected thus far give every assurance that they will easily survive a year's exposure.

Referring to the statement that, "the question really is the lifetime of the spacecraft itself, whether it is made to fully utilize the power that long . . ." suggests absolutely no doubt regarding the longevity of the nuclear power unit. This seems to reflect more subjective pride than objective reality.

At the risk of reflecting some of that same subjectivity, it seems fair to state that the Lockheed *Agena* vehicle, radiation hardened command, control and data systems, are no more likely to influence the mission lifetime than will the thermoelectric conversion cells, NaK circulating system or electronics.

I believe it is more important to find merit in the great step our country has taken in the new technology and the *team* effort that made it possible.

J. K. Zaleski
Sr. Research Engineer
Lockheed Missiles & Space Co.
Sunnyvale, Calif.

Turbulence Amplifiers

To the Editor:

I find some of the statements on pages 21 and 46 of your special report on Fluidics (M/R, Feb. 8) subject to contention. In one of your articles you give a brief history which cites two individuals, Chichester A. Bell and R. E. Hall, as having something to do with turbulence amplifiers. In the next paragraph you mention Henri Coanda to more or less summarize the pre-1960 activity related to the field. In contrast, G.E.'s report for NASA, "Fluid Amplifier State of the Art," contains a brief history (Vol. 1, p. 1-2) which mentions neither Bell nor Hall but does cite a number of generally recognized pioneers: Tesla, Coanda, MacMahone, Braithwaite and Wilcox, Todd, Kline, etc. What significance is there in M/R's mention of Bell and Hall with respect to the turbulence amplifier? Where in the literature on the field is this link made? Could it be that M/R is expressing the position of someone trying to create evidence which might be of use in a future patent infringement suit?

The term "turbulence amplifier" was first coined by me in 1961 to describe a device which I invented for use in pneumatic control circuits. The turbulence amplifier is a NOR with many advantages as a logic element and signal amplifier in practical circuits. Many thousands have been built and sold, and we are ready to substantiate our claim that the turbulence amplifier is the most widely used fluid amplifier in industry today and that *only* turbulence amplifiers are being used in large working (not demonstrational) industrial control systems. Some of these systems employing over 100 amplifiers have been in use nearly two years to control production machinery in daily service. During 1965 many thousand turbulance amplifiers will be used in industrial control systems here and in Europe.

In looking at prior developments to see what inventions might resemble the turbulence amplifier, most searchers find R. E. Hall as the only likely contender. Hall used the well-known sound sensitivity of long laminar streams to detect the sound of a buzzer. His object was to operate electrical contacts as the result of the ringing signal in a telephone circuit. His device used an electrically driven sound source with two types of pressure switches to accomplish its objective, with a laminar stream as the sound-detecting mechanism. The design of the turbulence amplifier requires the minimization of sound sensitivity and a structure which creates a practical interconnectable pneumatic amplifier. The reader of Hall's patent could no more see a NOR, flip-flop, or OR resulting from its structure than the observer of a crystal microphone could see a solid-state logic module resulting from its structure. I think that M/R should study the facts and the literature and see if there is any basis for the statement that Hall "developed a turbulence amplifier used as a logic control device."

Raymond N. Auger
Raymond N. Auger & Co.
Fluid Logic Control Systems
New York, N.Y.

AEDC Article Cited

To the Editor:

The article by Don Zylstra, "Re-entry Simulator Will Employ MHD" (M/R, April 5, p. 24), is a credit to both the author and MISSILES AND ROCKETS. All of us here at AEDC think that Mr. Zylstra did a masterful job of handling a very complex subject in a most comprehensive manner.

Lee V. Gossick
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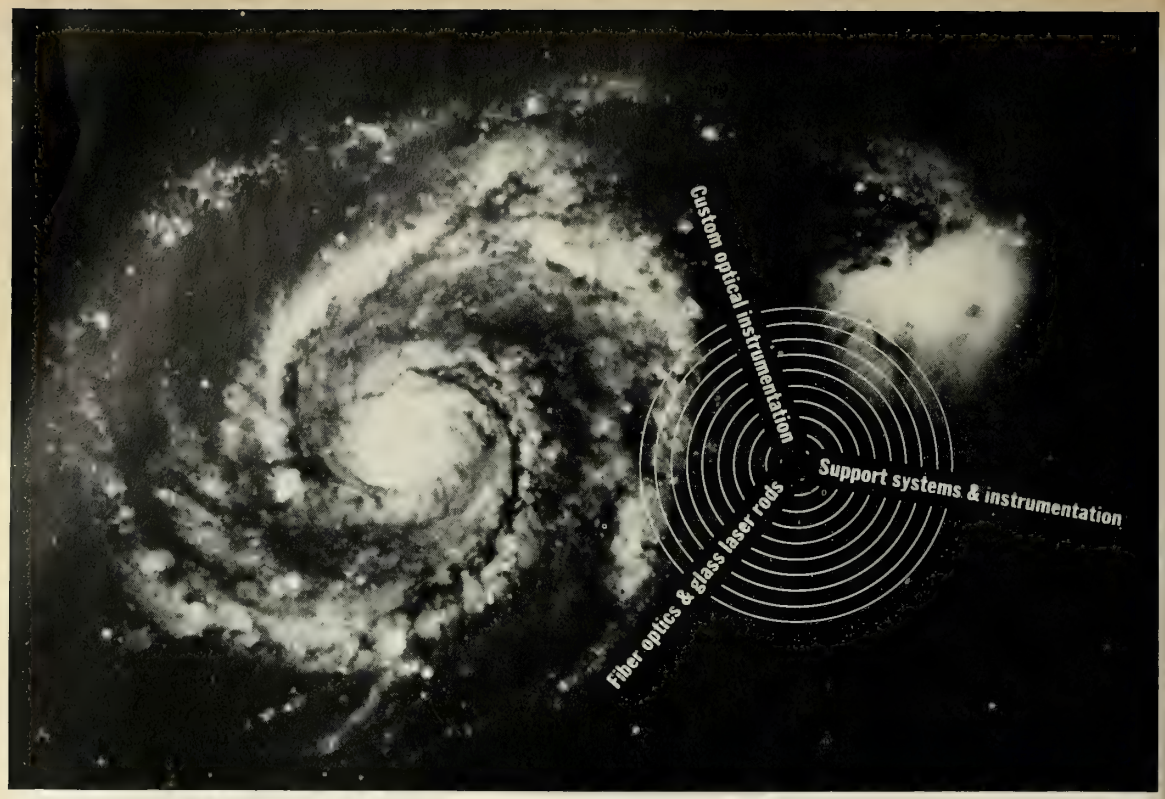

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The Countdown

WASHINGTON

F-111B May Have Phoenix, Sparrow Mix

A return to the original concept of making the F-111B *Phoenix* fire control system compatible with the *Sparrow* missile seems likely. Contracts are being negotiated by Navy with Grumman and McDonnell to study feasibility of using a mix of *Sparrow* and *Phoenix* on the aircraft. While in general war the policy would be to engage any radar target not identified as friendly, in brush-fire wars visual identification of airborne targets often would be necessary. In such cases, the F-111B already would be closer than minimum effective range for *Phoenix,* hence the requirement for *Sparrow*.

House Seeks Titan III-C for Surveyor

The House Space Committee has asked NASA to give serious consideration to adapting the *Titan III-C* booster as a backup for the *Surveyor* spacecraft program. The group pointed out that it still has reservations that *Centaur* will meet its schedule in view of its past history.

NASA To Select Scientific Astronauts

National Aeronautics and Space Administration is expected to select 10 to 20 scientist-astronauts next month. National Academy of Sciences has recommended a group made up mostly of male civilians with doctorates in physics, geology, astronomy, engineering and medicine.

McNamara Voices Support for Poseidon

Secretary of Defense McNamara has re-emphasized his support for the *Poseidon* missile system. He told the House Armed Services Committee he strongly favors the missile because both its increased accuracy and added payload will assist in penetration of any enemy anti-ballistic missile systems.

Electronics Center Site Is Threatened

Unless the local urban renewal argument which is holding up site purchase for the new NASA Electronics Center in Boston is settled soon, an effort may be made in Congress to move it elsewhere. That warning came last week from Rep. Albert Thomas (D-Tex.), chairman of a House Appropriations subcommittee.

Moon Landing May Be on First Trip

NASA is studying the possibility of accomplishing the manned lunar landing on the first flight of *Apollo* to the Moon. This would eliminate plans to make a circumlunar orbit and return before the actual landing effort. Decision could depend on the information returned by *Surveyor* and *Lunar Orbiter.*

Army Interested in Laser Missile

Army is funding industry studies of a new ground-to-air missile with laser guidance. This would have a definite advantage over current infrared missiles which are dependent upon tail-chase. Air Force also has an interest in an airborne version.

Navy Studies New MOL Project

Navy is considering a new project for the *Manned Orbiting Laboratory* other than the P-13 ocean surveillance experiment on which bids were due last week. The new program would be developed in two phases: project definition and full-scale development and demonstration with limited production quantities of a classified manned system. Naval Air Development Center, Johnsville, Pa., is seeking R&D sources.

Apollo Extension Funds Set at $100 million

NASA is seeking $100 million in FY 1966 for the program definition of its *Apollo Extension System.* Of this, $48 million is included in the manned spaceflight budget. The remainder of the funds are not specifically ticketed for *AES* but are part of the budget of the Office of Manned Space Sciences. Other funds are available in the budget for the development of the *Saturn IB/Centaur* launch vehicle.

INDUSTRY

Apollo Range Studies Awarded

Douglas Aircraft and Collins Radio have been awarded parallel four-month study contracts for the *Apollo* Range Instrument Aircraft Program. The program definition contracts of the eventually multimillion-dollar program provide $662,000 to Douglas and $595,000 to Collins. Eight C-135 jet aircraft will be modified for use in monitoring spacecraft launches and re-entry.

In the Front Office

Bernard J. O'Keefe has been elected president of Edgerton, Germeshausen & Grier, succeeding Kenneth J. Germeshausen, who becomes chairman and research director. Germeshausen succeeds Harold Edgerton, who asked to be relieved of his duties as chairman to give more time to oceanography and stroboscopic lighting research . . . Martin Co. public relations director Roy Calvin has been named a vice president . . . Vice Adm. (Ret.) Robert B. Pirie has been appointed chairman of Aerojet-General shipyards, Jacksonville, Fla. Since his retirement from the Navy in 1962 as Deputy Chief of Naval Operations, he had been executive assistant to the Aerojet president in the company's Washington office.

INTERNATIONAL

Soviets To Display Vostok at Paris

The Soviet Union is planning a major exhibit at next month's Paris Air Show. In addition to an aircraft display, the Russians also will have the *Vostok* space capsule on exhibit, with a Russian astronaut in attendance.

French Plan FR-1 Launch This Year

Spokesmen for CNES, the French National Space Center, still are hoping the first French satellite, *FR-1,* can be launched by a U.S. *Scout* before the end of the year. First CNES satellite to be put up by a French-built rocket still is scheduled for early 1966. Work on the two satellites is under way at the Bretigny Technical Center of CNES.

ESRO To Buy Four Delta Vehicles

European Space Research Organization (ESRO) is planning to purchase at least four *Delta* launch vehicles. Political wrangling over the ELDO booster has delayed that program and the *Deltas* will be needed during the 1968-69 period.

Nike-X Called Top Priority

The *Nike-X* anti-missile weapon is the highest priority item in the development program of the Directorate of Defense Research and Engineering, according to testimony by Dr. Harold Brown, director of DDR&E.

In recently released, censored testimony before the House Armed Services Committee, Brown said the funding of the *Nike-X* is just short of the procurement stage.

The request for $390 million for RDT&E and something over $3 million for military construction "actually contains some production planning money; that is, engineering money," said Brown. Although the request does not include procurement money, $10 million is for engineering necessary before procurement can take place, he pointed out.

Apollo Guidance Award

Kollsman Instrument Corp. has received a $43-million contract from the AC Spark Plug Div. of General Motors Corp. to build *Apollo* navigation equipment, including star-tracking and other in-flight celestial data navigation devices.

The pact also includes two wide-angle telescopes, one a sightline device for *Apollo* and the other an alignment instrument for the Lunar Excursion Module.

Prototypes of the celestial navigation equipment are presently under test at Kollsman and subcontracts are to be let for electronic components, angle readout devices, large beryllium parts, ground support equipment and other equipment required for flight hardware.

House Body Favors MOL

The House Armed Services committee has recommended a cut of $20.9 million in Air Force military astronautics research and development, but gave a high endorsement of the *Manned Orbiting Laboratory* program.

In making the cut, the committee made it quite clear that it believed it would leave funds in the astronautics category sufficient to support *MOL* at the requested level of $150 million in FY 1966. "The committee fully supports the objectives of this program and urges the Congress to give it support, if we are to take full advantage of our previous and future accomplishments in space."

The cut, explained in reporting out the FY 1966 DOD authorization bill, was made on the basis that the *Titan III* booster has progressed on schedule and within its funding estimates to the point where it will require approximately $125 million less for development next year. It also pointed out that the amount the committee has left is $65 million more than last year's authorization.

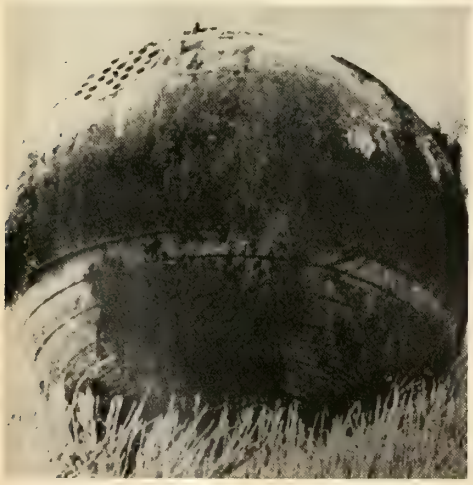
The committee finally issued its report to the House last week, after reversing its initial action which reduced more than $900 million from the $15-billion request. Total funding recommended in the bill the committee will now bring to the floor is $15.3 million, some $6 million above the actual request.

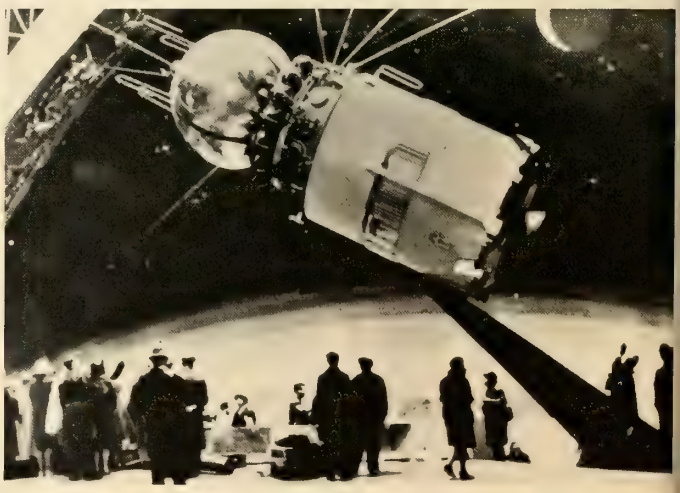
Like the Senate Armed Services Committee, the House group added $150 million for development of a guided missile frigate, accounting for the final plus factor in the bill.

Cuts of $25 million, which the committee termed a "relatively small" amount, were made in missile support equipment and facilities procurement for the Air Force. Five million also was cut from procurement of industrial facilities by the Air Force, with the view that good planning can overcome this cut.

In research, development, test and evaluation, the committee cut $114.3 million.

Although the committee made the





Soviets Say These Are Vostok Spacecraft

SPHERE at left has been identified by official Communist source as a Vostok space capsule after its return from an oribtal space flight. No date for the flight has been given. The photo was released in Moscow in connection with an economic achievement exhibition. Capsule, shown to the public for the first time, is said to weigh 2½ tons, and is described as being similar to the one in which Cosmonaut Yuri Gagarin became the first man to orbit the Earth. Spacecraft at right has also been identified as a Vostok in its first public exhibition in Moscow. Instrument section is to right of manned sphere.

cuts with specific programs in mind, it said that it would not bind DOD to cutting these programs, and that it could apply the reductions as it chose.

McConnell on Space Defense

Air Force Chief of Staff Gen. John P. McConnell has given the Air Force Scientific Advisory Board the primary project of developing an ICBM and space defense system using something other than missiles as the defense instrument.

Gen. McConnell told a luncheon at the National Press Club in Washington, "We still must continue to improve on existing systems, such as missiles, and we still must endeavor to exploit promising known phenomena such as the laser. However, there are some specific requirements which perhaps could be met better and more effectively through bolder approaches and through the discovery of new phenomena or revolutionary techniques.

"For instance, it is generally taken for granted that the best, if not only, possible defense against hostile ICBM's is another missile, an anti-ICBM missile. This may well be the case, but, conceivably, there is some phenomena or technique waiting to be discovered that might eventually lead to a far more effective system for preventing any hostile missiles from reaching our shores. If such a system could be conceived and developed, it would mean a tremendous boost to our deterrent posture."

IMP Integration Award Made

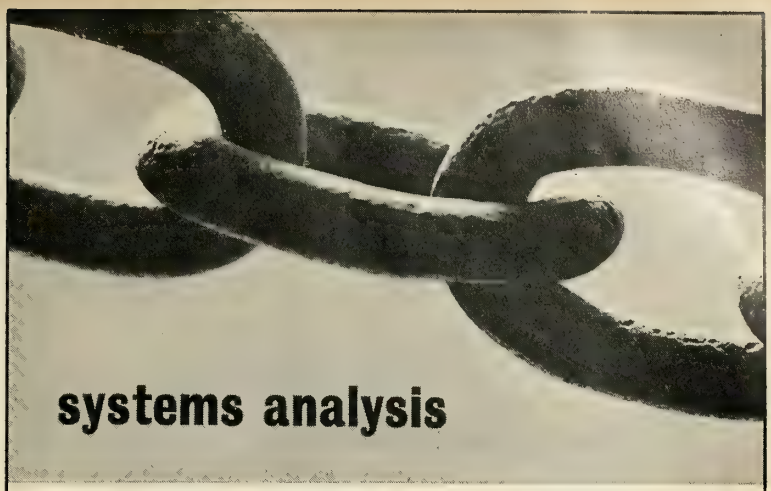
Goddard Space Flight Center has named Electro-Mechanical Research, Inc., to handle integration of two *Interplanetary Monitoring Platform* (*IMP*) satellites.

Under the $757,000 contract, EMR will assemble *IMP's F* and *G* and provide necessary mechanical and electrical integration, qualification tests and pre-launch and post-launch support.

The scientific satellites are advanced versions of the *IMP* series, designed principally to gather information on conditions at the outer border of the Earth's magnetic field. The spacecraft are also expected to provide data needed for designing protective shielding and environmental systems for manned spacecraft for lunar missions and beyond.

Thiokol Fires Wafer Motor

A restartable solid motor consisting of five 12-in.-dia. solid propellant wafers developed by Thiokol Chemi-



It is obvious that the chain is no stronger than its weakest link and thus, with one weak link, needless expense has gone into the manufacture of the other stronger links. In the conception and development of today's complex defense and space exploration systems, the number of "links" or subsystems are many, their individual relationship to the rest is complex, and the need for careful balance or trade-off between these "links" is mandatory if the end mission objectives are to be attained. The answers in this environment are no longer obvious and it is the Systems Analyst or Systems Engineer who must provide the needed guidance so that each "link" is developed to properly fit its role in the total system.

At Grumman, Systems Analysts are providing this guidance in a continuous manner from the initial concept or problem definition phase through the phases of synthesis and analysis, choice of alternatives, detailed system mechanization and finally into the verification phase which includes simulation and test evaluation. These Systems Analysts are engaged in such Systems as Manned and Unmanned Space; Attack; Airborne Early Warning; Reconnaissance, and Anti-Submarine Warfare.

At Grumman the strongest links in the chain of profession advancement are growth and stability. Systems oriented engineers and scientists seeking a real challenge for their talents are cordially urged to explore the following specific opportunities.

Carrier Suitability Systems Engineers—BS or advanced degree with minimum of 1 year experience in establishing operational compatibility of a given weapon system with ship facilities and ship installations. Operational experience is highly desirable. Will establish high density and/or mixed complement aircraft spotting characteristics, investigate aircraft and ordnance handling, and verify the compatibility of related support equipment and facilities with the aircraft carriers concerned and/or other operational sites and vehicles.

Systems Coordination Engineers—Will coordinate a program that organizes, validates and controls that over-all functional requirements of an advanced manned spacecraft project fulfilling project objective as prescribed by the procuring agency. These functional requirements are translated into over-all vehicle performance and design requirements; establishing systems parametrs from which the vehicle, its major subsystems, and support equipment are designed. Task assignments include: internal and external liaison with design specialists & systems personnel & direction of the incorporation of established requirements into top systems and vehicle specifications. Applicants should possess a BS or MS in ME, EE or Physics and a minimum of 3 years of systems analysis or integration experience in a major systems effort.

Systems Engineers—Facility and Services—BS or advanced degree with a minimum of 2 years experience in establishing the requirements for facilities and the criteria for the evaluation of existing facilities. Applicants will be required to survey Test and operational sites both ashore and afloat to verify weapon system compatibility with existing facilities and support equipment. Ability to recommend and/or originate solutions to preclude potential interface difficulties is necessary. Recent military experience and/or good working knowledge of military organization desirable.

Mission Analysis Engineers—Plan LEM missions and determine related spacecraft functional requirements. Normal and emergency operations during both development and lunar landing missions are to be considered. The work will involve contact with engineering and test sections at all levels. A minimum of 5 years experience, preferably in systems analysis, preliminary design or operations analysis, is required.

Attack and Reconnaissance Systems Engineers—BS or advanced degree with a minimum of 3 years experience in over-all development of airborne attack and reconnaissance systems. Knowledge of components which comprise these systems, such as analog and digital special purpose computers, displays, sensors, including radar, inertial platforms, IR and visual or photographic inputs, guidance and control, and autopilots is essential. Duties include: definition of the requirements for the systems, analysis and synthesis of the systems, simulation, and flight development for final verification.

To arrange an immediate interview, SEND RESUME to Mr. P. W. Van Putten, Manager Engineering Employment, Dept. GR-86.

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There must be a better way.

Iced tea. Mint juleps. Skinny dipping at midnight. A small ivory fan. Beer. Sno cones. Skinny dipping at noon. Ice bags. Electric fans. A tall glass of cold water. Skinny dipping before dinner. Tom Collins. Popsicles.

All very well and good, but when we're talking about astronauts and space vehicles, none of them seem to make sense. Astronauts and the instruments they use tend to get pretty hot under the collar up there. And you know how grumpy *you* get when you're hot and sticky. So Hydro-Aire came up with the answer—liquid coolant pump assemblies. Apollo will use them. The Lunar Excursion Module will use them. The Saturn C-V uses them.

Hydro-Aire has had over 20 years experience in electro-mechanical, electric and fuel system engineering, but this problem demanded something else again. It's easy to do what you've been doing for 20 years, but when you're talking about completely new methods and components, that's another matter. We came up, for instance, with the Invermotor. (*Ed. Note: These marketing/sales/advertising people can really obfuscate things. The Invermotor is a brushless DC motor. Can't you just see the conference? "Let's get a name for this thing." "How about Brushless DC Motor?" The guy that came up with that one probably hasn't been heard of since.*) What Hydro-Aire does is hermetically seal the stator in a canned package. This way we can eliminate the unreliable shaft seals and allow fluid to be used for internal motor cooling and lubrication. Motor windings can be completely isolated from corrosive fluids.

Now back to all that experience. We build centrifugal pumps and all types of positive displacement pumps—vane, piston and gear. We build all the motors and drives to drive them. And we not only design them, we build them right in the house. What we're really leading up to in not too cool a fashion is: you *must* have some problems in critical fuel pumping for space technology programs. You know. Something really hot.

HYDRO-AIRE

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cal Corp. has been started, terminated and restarted five times at the firm's Wasatch Division.

Each wafer has an individual ignition system and is separated from its neighbor by thermal barriers of either epoxy or rubber materials. Thiokol did not reveal thrust levels, firing times, pressure levels or any details on the motor itself other than the wafer configuration. Six earlier tests involved double-wafer restartable motors in developing the thermal barrier system.

The program is a company-funded effort and additional tests are scheduled.

Voyager Team May Grow

The Boeing Co. may expand its Project *Voyager* industrial team—probably in the areas of propulsion and attitude control.

According to Edwin G. Czarnecki, Mars exploration program manager for the firm's Aero-Space Div., Boeing is discussing possible additions of large companies in the two specialized fields to the team.

The Boeing team now includes Philco Corp., which will handle telecommunications, and Electro-Optical Systems, Inc., which would provide on-board power systems.

Shots of the Week

NASA on April 29 successfully orbited *Explorer 27* (*Beacon Explorer-C*) from Wallops Island, Va. The 132-lb. geodetic and ionospheric environmental study satellite attained a higher orbit than was intended, but was operating as planned. The satellite differs from an almost identical *Explorer 22* launched last Oct. 9 in that its primary mission emphasis is on geodetic measurements. It also carried a detector to confirm laser beam contact, an accomplishment presumed for *Explorer 22* but not verified. A radio attenuation measurement (RAM) experiment that was to have gone aloft with the satellite's *Scout* vehicle was removed before launch because of mechanical difficulties.

New Role Seen for FLIP

The Floating Instrument Platform (FLIP), an anti-submarine warfare research vessel, may find use as both a missile launcher and a space vehicle tracking station.

Success in stabilizing the vessel in heavy seas has led to NASA interest in Sea Legs, a concept similar to FLIP and conceived by the same designer.

In operation through storms of gale force with waves up to 35 ft. high, vertical movement of the FLIP vessel was 3 in. Designers and operators say it would be possible to cut down drift of the vessel to the point where it could maintain position as a tracking station. The Sea Legs concept could provide an equatorial launch capability for spacecraft, program spokesman said.

U.S., Brazil To Launch Rockets

The United States and Brazil have agreed to carry out a joint program starting this fall to study effects of cosmic rays in the lower ionosphere.

The project, announced last week by NASA will be part of the International Cooperation Year. It calls for launch by the Brazilian Space Commission of two *Nike-Apache* rockets from the Brazilian range at Natal, and the firing of a third, complementary rocket from NASA's Wallops Island, Va., station.

NASA said Brazilian technicians are now training for the experiments at Goddard Space Flight Center and Wallops and that Brazilian engineers will construct the two Natal payloads at Goddard.

Hydrazine Thrustor In Offing

A 0.5-lb. thrust monopropellant hydrazine control rocket will be built by Rocket Research Corp. for NASA's Goddard Space Flight Center.

The program is one of the first to use a new hydrazine catalyst developed by Shell Research Labs.

The catalyst causes hydrazine to spontaneously decompose into hydrogen, nitrogen and ammonia gas—making it possible to utilize the fuel in a monopropellant application. The low temperatures of the exhaust gases and their relatively low molecular weight provides significant performance gains over other monopropellant and bi-propellant systems.

Early Bird Inaugurated

Television demonstrations using the *Early Bird* communications satellite will continue this month by networks and broadcasters in the United States, Canada and Europe.

Meanwhile, the Federal Communications Commission is expected to rule this week on ownership and control of initial ground stations for the international communications system. The issue has been pending since last August.

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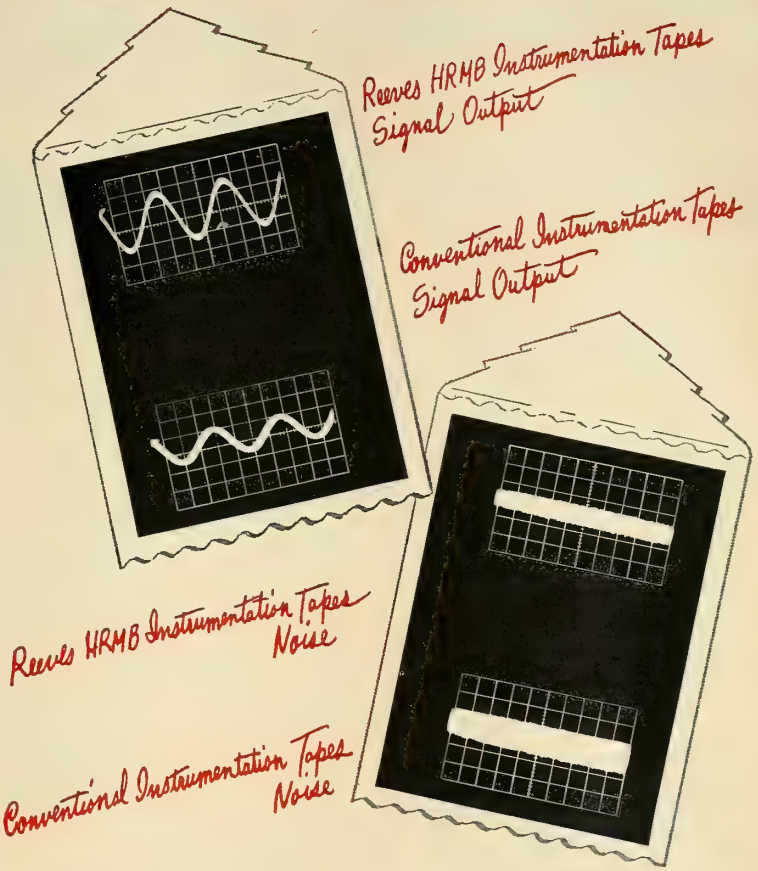
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Russians Report Mars Probe Failure

Unprecedentedly large volume of reports on Soviet space effort also includes findings from Cosmos, Elektron and other satellites

by Hal Taylor

CHICAGO—Soviet scientists have disclosed—as part of the largest release to date of information on the Russian space program—that the *Zond II* spacecraft moving toward the planet Mars has stopped transmitting data back to Earth.

In technical papers presented at the Post-*Apollo* Space Exploration Symposium here, the scientists discussed results from many of their unmanned satellites. They did not, however, offer any information as to their future plans in either unmanned or manned flight, except to note that they are interested in the distant planets and in probes to the Sun.

Physicist Gennadiy Skuridin, head of the Russian delegation, said that the cutoff of *Zond II* apparently resulted from a failure in the probe's solar panels caused by the impact of meteoroids or by solar radiation.

Skuridin's remarks were part of a surprisingly large flow of information on the Russian space program provided by interviews and six technical papers which were presented by the Russians at the symposium, jointly sponsored by the American Astronautical Society and the IIT Research Institute.

REAR VIEW of full-scale wooden mock-up of Boeing MOLAB (mobile lunar laboratory) described in paper presented by the company at the AAS-IIT Post-Apollo Symposium in Chicago. Astronaut is shown in early-design pressurized, Apollo-type spacesuit entering cabin's main hatch. Total internal volume of MOLAB cabin is 290 cu. ft. Boeing headed one of two teams conducting competitive MOLAB studies.

● **High points**—Other data on the Russian program included:

—Present Soviet scientists have all the technology in hand to perform an orbit-changing space maneuver and two USSR flights with unmanned satellites, labeled Flights One and Two, actually did maneuver in space. The Soviets did not claim that they had done this on any of their manned flights, but declared that the *Voskhod II* spacecraft had such a capacity.

—Cosmonaut Alexei Leonov, during the extravehicluar experiment on the *Voskhod II* flight, carried his life-support equipment on his back, but did not have any propulsion device with him. The Russians plan more of these experiments in an effort to determine how man can function in space and what tasks he can perform in the linking up of multi-man spaceships. This, plus their stated belief that achieving orbital rendezvous is still one of their major space problems, just about solidified previous reports that they will use in-orbit spacecraft building as their method of achieving long-distance manned flights.

—Cosmonaut V. Bykovsky, who survived five days of manned spaceflight, is still in good physical condition, and this is encouraging to Russian space scientists. Oleg Gazenko—identified as a space medicine specialist—said that he personally is pushing for more Russian spaceflights with animal passengers. He said that such flights, using either dogs or monkeys, are necessary to gather data for manned flight technology.

—The Russians don't consider landing a man on the Moon a major space feat because the science of space flights has too many technical problems to concentrate on such an effort. They also said that they do not think that spaceflight science should be considered a "sporting event or a race."

While apparently giving the impression that the Soviet Union is not racing the U.S. to the Moon, the scientists pulled a quick switch and said that before they could decide to land on the Moon they had to solve such problems as determining the best way to orbit multi-manned vehicles in Earth orbit, achieving rendezvous, and studying the lunar surface to locate a suitable landing site.

● **Space buildup**—In discussing the investigation of space in the USSR, Skuridin said Soviet scientists understand the problem of going to the Moon and are now studying it vigorously.

He said that beginning in 1962, the Russians started the study with the *Cosmos* series of spacecraft. This continued in 1964 with the *Elektron* series. All of these were launched from several pads at an undisclosed Cosmodrome. The weight of the satellites varies from several hundred kilograms to several tons. They are modified to suit the re-

quirements of various missions and carry such equipment as thermal control units, scientific instrumentation, data recorders and storage systems, radio telemetric systems and braking systems to return them to Earth when necessary.

In the *Sputnik* series, he said, two satellites were placed in widely different orbits through the use of a single rocket carrier.

The *Elektron* series was assigned the job of carrying out the broad study necessary to obtain a deeper understanding of the processes which take place in the cosmic area closest to Earth.

Part of the mission of the multi-manned series was to measure the nuclear radiation in space created by high-altitude nuclear explosions. On one of the multi-manned spacecraft in the series, two blocks of equipment—one inside the spacecraft and one outside—were carried. Measurements were taken of the high energy as the gamma quantity of the radiation which penetrated the outer shell and entered the inner block of measuring instruments. While he did not reveal the measurements taken, he indicated that the radiation, even when large amounts were in the atmosphere, presented no roadblock to manned flight.

The *Cosmos 41* satellite recorded the study of charged particles at an altitude of 40,000 mi. Skuridin said another *Cosmos* satellite recorded a great cycle of successive ionospheres through the use of what was called a radio station beacon.

Cosmos 3 and *4* studied solar plasma, its energy and location in Earth areas for over a year. From the period of April 24 to May 2, 1962, more than 50 million measurements of direct transmissions were sent back to Earth and 20 million more were stored in a data-storage system.

The *Elektron* series, he continued, made important measurements of the atmosphere up to an altitude of 3,000 kilometers. The ions of hydrogen, carbon and oxygen were also measured. Oxygen ions registered up to altitudes of 1,000 kilometers and carbon ions registered almost as high. Hydrogen ions were registered at altitudes ranging from 406 to 3,000 kilometers.

In discussing future flights, Skuridin said the Soviet Union would like to study Saturn, Pluto and the Sun. What is needed, he said, is a satellite which can be launched out to far-off planets and the Sun and return to Earth. ■

Three Top Contractors Planned for AES

CHICAGO—Preliminary plans for the development of the *Apollo Extension System (AES)* now call for the selection of three major spacecraft contractors.

In addition, many other contractors will be required to develop and build the experimental packages to be flown in the program, a NASA official told MISSILES AND ROCKETS last week.

One firm will be selected to come up with a single payload plan covering all flights in the program, which could grow to as many as 19. The award will be termed the requirements integration contract. It is expected to go into the program definition phase early in Fiscal Year 1966.

The second industrial contract will cover the physical installation of the experimental payloads into the spacecraft and then systems checkout prior to launch.

The third contractor will be responsible for taking the *Apollo* spacecraft and translating it into the *Apollo* extension vehicle, which will have a manned orbiting capability of at least six weeks. Program definition work will be initiated on both of the latter awards later in FY '66. Hardware development will be initiated with FY '67 funding.

● **Single contractor unlikely**—The space agency official said that while there are many missile/space industry firms that could perform all three chores, this is not likely to happen. He said that it is far more probable that the agency will select a separate contractor to do each of the three tasks.

He said this approach stemmed from a reluctance to depend on a single contractor for the whole spacecraft project as well as a desire to use broad-based, readily available industrial capability.

He said that further *AES* feasibility and design studies will be awarded to industry in the near future. They will be paid for with funds authorized in the NASA FY '65 budget, as well as the FY '66 program, which has not yet been approved by Congress.

● **Disciplines included**—Approximately 12 contracts will be awarded and will cover experiments in such areas as Earth sciences, astronomy, biosciences, space physics, the medical behavioral area and lunar orbital missions.

The official stressed that current plans for *Apollo Extension Systems* are still in the preliminary stage and have not yet been approved by Dr. George E. Mueller, Associate Administrator for Manned Space Flight, or other high-level Headquarters officials.

His comments were made at the symposium on post-*Apollo* space exploration being held here under the joint sponsorship of the American Astronautical Society and the Illinois Institute of Technology Research Institute.

A host of NASA and industry officials presented papers dealing with the plans and requirements for future manned and unmanned flights in Earth orbit and to the Moon and planets.

Highlights of the May 4-6 meeting included:

● **Upper stage effort**—James B. Kendrick of TRW Space Technology Laboratories revealed that the space agency later this year will begin the preliminary design of a high-energy upper stage. According to NASA officials in Washington, hardware funding would begin in FY '67 if the program is approved.

He said the 7,000-lb.-thrust fluorine/hydrogen stage could be used for a variety of missions, including 24-hour synchronous orbits, planetary and gallactic probes and the 0.1 AU solar probe.

Quoting data obtained during a study contract for NASA, Kendrick said that STL had come up with 412 missions that could use the stage over the next decade. He said that minus R&D cost, the price of that number of launches of the stage by the *Thor-Delta* would be $458 million; *Thor-Agena,* $282 million; and the *Titan II/Agena,* $766 million.

● **Mars fly-by outlined**—A representative of Douglas Missile & Space Systems Div. presented a plan for a manned fly-by of Mars in the 1970's that would use existing *Saturn V/Apollo* technology.

The major new development for the proposed flight would be the *Manned Orbiting Research Laboratory* at a cost of $3 billion. In addition, the Mars fly-by costs were estimated at $1 billion. The proposed mission calls for two *Saturn V's* to put loaded S-IVB stages into orbit.

A six-man *Apollo* spacecraft would then be launched and docked with the stages. Then the *MORL* would be placed into orbit for a full month's checkout of the spacecraft and stages. The first S-IVB would then be fired to put the *Apollo* and *MORL* into a highly eccentric orbit and the second to send them on a Mars trajectory.

Melvin K. Root, manager of *Saturn* extension studies at Douglas, said that such a flight will be essential before the U.S. can embark on a multibillion-dollar manned Mars landing program.

TOW, Shillelagh Face Showdown

Helicopter-mounted armor killers are only two of many systems whose fate will be sealed in Army's tactical 'year of decision'

by Donald L. Zylstra

HUNTSVILLE, ALA.—The Army is facing a decision within the next few weeks between two versions of helicopter-mounted anti-armor missile weapons.

The choice is between the Hughes Aircraft *TOW*, a wire-guided system weighing 160 lbs. total, and Philco Aeronutronic's *Shillelagh*, also originally designed as a lightweight surface-to-surface command-guided weapon.

Stabilized, vibration-correcting sights for directing these weapons have been developed by Hughes and Philco Aeronutronic, respectively, to insure optimum system operation from Army's Iroquois (UH-1B) helicopter.

This decision between two versions of a surface-to-surface weapon adapted for deployment in the air-to-ground mode is only one of several pending in the near future, during what is being described as "the year of decision" for Army's tactical missile development program.

● **MAW competition**—Competition continues between two versions of the *MAW*, a shoulder-fired anti-tank weapon designed for use at the company level as both move rapidly toward feasibility demonstrations.

Army negotiated a $2.8-million contract in August, 1964, for exploratory development of one version of *MAW*, submitted as an unsolicited proposal by McDonnell Aircraft. This wire-guided missile will shoot it out with Army's hyper-velocity "two-degree-of-freedom," free rotor-guided version at the Missile Command here within the next few months. Total funding of development of the two versions to date has been less than $5 million.

MAW is being developed to fill the need for a man-carried system with a warhead big enough to kill most armor encountered on the battlefield. *MAW* is also to provide major improvements in range. Both solid propellant versions now contemplated are estimated to have a range of 500-1,500 yards.

In its development of *MAW*, McDonnell has followed many of the wire-guided concepts the firm developed as a competitor in the *TOW* design effort. Like the Army's in-house version, it is launched out of a tube supported on a simple bipod and can be fired by one man, sitting, or in the prone position. To eliminate the need for the gunner "keeping his head up," Army's in-house approach to *MAW* design has moved toward an exceptionally fast missile with a very simple guidance, with the missile following the line-of-sight established during the instant the gunner first draws a bead on his target.

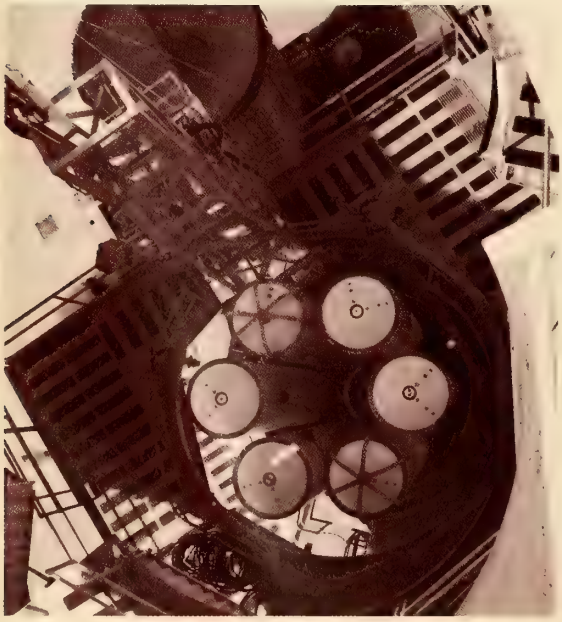
● **One-shot kills**—In approaching its second-generation battlefield missiles, the Army has stressed the need for first-round kill and better range from a lighter weight system—with ruggedness, reliability and simplicity of operation at a cost that will permit deployment of sufficient numbers in combat.

"Today's technology makes it possible to develop a missile or rocket capable of meeting all these diverse requirements separately and, in some cases, collectively," says Maj. Gen. John G. Zierdt, commander of the Army Missile Command.

Ideally, Army commanders would like to provide all areas of the battlefield—from the front lines to rear-echelon areas—with weapons that will kill tanks wherever they are encountered and, similarly, with both man-carried and longer-range weapons that are effective at any point against enemy aircraft.

Man-transportable weapons for the infantry in the front lines should not exceed 30 lbs., or at the maximum they must be designed with components of about this weight, transportable by only three or four men and capable of rapid assembly into a firing system.

TOW, in its surface-to-surface configuration, is a good example of this type of weapon. With a total weight of 160 lbs., it is tube-launched from a tripod and three men can carry all its



Little Joe Gets More Engines

SIX Aerojet-General clustered Algol solid motors (seen from above) will give Little Joe II booster 620,000 lbs. of thrust for upcoming test of Apollo launch escape system developed by Lockheed Propulsion Co. System will boost spacecraft 22 miles above White Sands Missile Range, N.M.

components. As a battalion-level weapon, it can be mounted on vehicles such as the M-113 armored personnel carrier.

● **TOW results good**—The 2,000-meter-range *TOW* is now in advanced development and Army R&D people and tacticians are pleased with its progress. *TOW* operation demands only that the gunner keep his sight cross-hairs on the target during the wire-guided missile's completion of its trajectory to impact. The missile is "slaved" to fly along the gunner's line of sight, with trajectory correction imparted to it automatically. No leading of the target is required.

Now phasing into production is *Shillelagh,* a command-guided missile for installation on the General Sheridan airborne assault reconnaissance vehicle, designed as a replacement for Army's light tanks. Sheridan has aluminum armor, can "swim," and is droppable by parachute.

The *Shillelagh,* with its conventional explosive warhead, eliminates wire guidance, but retains the "slave" trajectory characteristics of *TOW*. Now undergoing service testing after completing its R&D checkout, *Shillelagh* is described as "highly accurate at ranges well beyond the usual 1,500-meter operation of conventional anti-tank guns."

Studies toward extending *Shillelagh* capability and range are supported by $4 million in Fiscal Year 1965 funding.

● **Saturation systems**—An approach to the solution of battlefield problems not answered by line-of-sight weapons is *MARS* (multiple assault rocket system), sometimes called *HARS* (heavy assault rocket system). West Germany is actively interested in this concept, but the United States has no current plans for developing it for its own use.

Basically, *MARS* is a long-range, low-cost, high-density concept, envisioning massed delivery of conventional high-explosive warheads to targets concealed from the gunner's view by terrain features. As presently conceived, *MARS* would fire 50 to 100 rounds of its missile—in saturation amounts, to effect its kill.

In approaching its short-range non-line-of-sight problems, the Army is still seeking reliable, economical methods of getting a missile to home on a tank. Studies of magnetic and noise "signatures" have been made, along with consideration of several versions of "optical contrast" seeker devices and investigation of the possibilities of infrared and radar seekers.

One of the promising concepts is a semi-active laser homing system. Here Army is studying the possibility of guiding missiles either to armor or to aircraft by coupling a man-portable laser illuminator with the operation of a missile equipped with a seeker that homes on the reflections from the laser's target.

● **Air defense weapons**—In improving its battlefield air defense, Army will depend on *Redeye,* now in early production, as its man-portable weapon. Although *Redeye* has obvious range and speed limitations, Army tacticians note that enemy aircraft speeding over the battlefield in attempts to out-fly *Redeye* will be penalized by being unable to perform their air-to-ground missions properly. Similarly, aircraft attempting to operate above *Redeye's* "ceiling" lose the advantages of nap-of-the-Earth protection and would then become a potential target for *Hawk* batteries.

With *Hercules* and *Hawk* the only truly operational battlefield air defense weapons, the Army is striving for better speed and mobility. Most accurate term for *Hercules* is "transportable," and while *Hawk* affords better mobility, Army would like nothing better than to prove its *Mauler* concept feasible.

Mauler, a system designed in hopes of a capability to "shoot on the move," was to be a multiple-target weapon with a capacity for rapid target engagement. Army and DDR&E R&D chiefs will be deciding "within about 90 days" what the fate of the *Mauler* system will be.

● **Misgivings about Mauler**—Privately criticized by some development people as "an overly ambitious attempt to package an entire *Hawk* battery on one vehicle," *Mauler* development was interrupted to permit the system to undergo a "feasibility validation exercise," now in its finishing stages. Although Army spokesmen pronounce this feasibility demonstration "encouraging," no responsible officer in that service will discuss its future, pending some new word from the DOD level.

Chaparral, a ground-to-air adaptation of the *Sidewinder* missile, is regarded by most Army commanders merely as an interim "quick-fix" system to fill an urgent air defense need, in view of the difficulty with *Mauler.*

Chaparral currently is configured as a four-missile launcher, now being adapted to a tracked vehicle of the M-113 type by Philco Aeronutronic. Firing tests are planned late this year at the Naval Ordnance Test Station, China Lake, Calif.

● **SAM-D status**—Army is evaluating a series of options its hopes will lead soon to authorization of a project definition phase for its *SAM-D* missile concept. Conceived as a multi-function system to afford battlefield defense against both aircraft and ballistic missiles, *SAM-D* is the latest in a progression of tentative answers to the battlefield air defense problem—beginning 10 years ago with *Plato* and progressing on down through *FABMDS* and *AADS-70.*

Teams headed by Hughes Aircraft and by RCA Defense Electronics continue to engage in competitive components development for the proposed system. Weathervane changes in DDR&E philosophy about what is needed in a *SAM-D* system seem currently to emphasize the need for defense against aircraft as the primary objective, and at the same time crank in whatever defense against battlefield ballistic missiles proves feasible.

Painful experience with *Mauler* in its attempt to mount an entire air defense system on one vehicle seems to prompt Army R&D officials and their industry associates to take a long, careful second look at the possibility of transporting the system on several vehicles. It is now apparent that what is needed isn't simply an upgraded *Mauler,* but a truly mobile system carried on a "reasonable number of standard ground vehicles."

In keeping with an increasing requirement that a single system replace several predecessors if possible, *SAM-D* is now viewed as a replacement for *Hawk* with its low-altitude capability and *Hercules* with its longer reach and range. Unlike the *Mauler* concept, which calls for shoot-on-the-move performance, permitting it to range the battlefield and even move up front when needed, *SAM-D* would tend to use its mobility largely for combat survival. ■

Rider Would Affect Patents

The Senate Space Committee, which is expected to complete markup of the NASA FY 1966 authorization bill next week, has been asked to consider a proposal to add a rider to the bill that would require NASA to retain title to inventions developed under R&D contract.

The rider, which would prohibit the Administrator of NASA from allowing advance waivers of patent rights during contract negotiations, is being pushed by Sen. Russell B. Long (D-La.) with the support of some other Senate members.

The move, however, is opposed by some industry groups including the Electronic Industries Association. The President has created a top-level commission to probe the patent system and seek ways to improve it, and it is expected to report in some months.

Should the Senate Committee decide not to act upon Long's suggestion, it is expected that he will offer it as an amendment when the bill reaches the Senate floor.

Off to heated start . . .

House Probe of Aerospace Corp. Begun

Spending, security procedures questioned; Zuckert, Schriever defend some actions and praise firm's performance

by Heather M. David

CRITICISM OF USE made of funds received from the government and a question of possible security irregularities were aired in the first heated days of the House Armed Services Investigating subcommittee probe of the activities of the Aerospace Corp.

The fund debate centered around a number of charges by the General Accounting Office of "questionable costs" —some of which were allowed as overhead and reimbursed by the Air Force and some of which came out of fees incurred by the company over the almost five years of its existence. Aerospace has received an average fee of 5% of the value of its work, amounting to about $16 million to date.

A major use of these fees, Secretary of the Air Force Eugene M. Zuckert told the subcommittee, was intended to be in "independent research" by the company. However, it is charged that only about $160,000 to date has been expended in this manner.

Both Zuckert and Air Force Systems Command Chief Gen. Bernard Schriever were highly laudatory of Aerospace achievements during its association with the Air Force.

The question of the security problem was brought out by subcommittee chairman Porter Hardy (D-Va.) in questioning Schriever. Rep. Hardy told Schriever that he was concerned about the security clearance of some of the personnel, and later told reporters that it appeared that there might be some improper clearances at Aerospace.

Indications were that the matter is related to reports written by a psychologist employed partly in analyzing personnel at the company. Hardy said the committee might go into executive session to discuss the matter.

● **Property acquisition**—Comptroller General Joseph Campbell, one of the first witnesses to appear, charged the company had acquired new buildings when Government-owned facilities were available and could have been furnished for its use.

Campbell said that the Government will incur extra costs of about $17.6 million because of these acquisitions, including one Government-owned property located across the street from Aerospace properties. Another small tract of land was acquired at Cocoa Beach, Fla., Campbell said, although the Air Force was building a facility at Patrick AFB that would have had space for Aerospace.

Hardy further charged the Air Force with using Aerospace as a device to get facilities Congress would not otherwise have approved.

In answer to these charges, Schriever told the subcommittee that GAO erred in saying that the property in San Bernardino was available, because it was not empty until some time later. He added that other facilities in question were World War I buildings, which would have been expensive to modify and maintain, and that he would not expect to be able to attract qualified people to work in such conditions.

● **Salaries**—A number of examples of high salaries paid employees, including the use of a 20% incentive bonus paid top executives was related by the GAO. In addition, annual salary increases of more than 15% to "many employees" were cited. The difference between the actual raise and the 15% was paid by Air Force fees, GAO said.

In attempting to answer these and other charges, Schriever told the subcommittee that over 97% of the salaries paid by Aerospace Corp. personnel are in the Government wage and salary scale, and that they compare with industry standards. The average technical staff member receives $17,755 and only 12 executives make over $35,000 a year. In response to committee questioning, he admitted that this did not include the 20% bonus available to some employees, but that to provide a fair comparison with industry, industry's practice of awarding stock options should also be considered.

GAO also quoted several instances of high percentages of sick leave days —in one case 53 days out of 177— taken by employees under Aerospace's unlimited sick leave allowance.

● **Moving expenses**—Another charge by the GAO was "unusual" relocation expenses allowed personnel in moving their households from one location to another. In one case, over $2000 was paid one employee, who lived some 50 miles away from the plant, and ended up further away from the new plant.

In addition, GAO charged, employees were allowed up to five days to "become familiar" with the new plant area at San Bernardino, although notice of some months had been given of the move, and the area was within easy driving distance from the original site.

● **Public relations**—It was disclosed that $1.2 million has been spent by Aerospace for public relations services. This included an advertising firm, Gaynor and Ducas, paid $2000 a month during the past few years. In addition, the Aerospace Corp. maintains its own staff of 16 for public information.

The subcommittee appeared especially irked when it was disclosed that one of the services of Gaynor and Ducas was to write a memo on how to handle testimony before the subcommittee, including advice to "play up *Titan III*."

This approach, however, was squelched early when the committee admonished Air Force Secretary Zuckert for including in his introduction of the Aerospace Corp. the fact that the *Titan III* was one of its accomplishments. The committee took the position that there were others who also were responsible for the *Titan III*.

The position of Claude O. Witze, senior editor of *Air Force and Space Digest*, as a public relations employee at $150 a month also was brought up by the subcommittee. His position was described as being "the eyes and ears" for Aerospace in Washington, and reporting to Aerospace headquarters, in spite of the fact that there is a sizable staff in Washington.

● **The psychologist**—Other accomplishments of the psychologist—who reportedly has earned $54,000 from Aerospace Corp. for 202 work days— were attacked. Reading a report on human factors written by the psychologist, Rep. Otis Pike (D-N.Y.) said "if it took him more than a half day at that price, it was no bargain." ■

Leveling Trouble Plagues Crawler

Problem with 16 hydraulic jacks has been under study since January; Saturn V/Apollo transporter contractors listed

by Sue Butler

CAPE KENNEDY—The huge crawler-transporter designed to carry *Saturn V-Apollo* to launch pads 39A and B at the Merritt Island Launch Area has leveling problems which so far have stumped its engineers.

Don Buchanan, project engineer for the Marion Power Shovel Co., Marion, Ohio, which holds an $11.2-million contract for two such crawlers, disclosed that the 16 hydraulic jacks that make up the unique leveling system are not working properly and cause corners to be plus or minus two inches out of plane.

The leveling system is designed to compensate automatically for loads up to 12 million pounds—the combined weight of the 11.5-million-lb. mobile launcher and the half-million-lb. assembled *Apollo-Saturn V* space vehicle.

Buchanan said the inaccuracy in leveling causes the signal to cut off automatically, shutting down the leveling system.

The problem in the electronic circuitry was discovered soon after the crawler was delivered for testing Jan. 23, but its source has not yet been traced.

● **Contractors**—American Machine and Foundry is responsible for the six-million-lb. crawler's hydraulic leveling and steering system.

Other firms subcontracting from Marion Power Shovel, which designed, manufactured and erected the machine's chassis, running gear and electrical systems, are:

—General Electric Co., Schenectady, N.Y., which provides the crawler's electric propel (drive) motors, high-voltage switching gear, control consoles and the 2,000-kw direct-current generators that supply the power for the propel motors.

—White Superior Co., New York, various electrical components, diesel engines to supply alternating current for the crawler and mobile launcher during transport operations.

—ALCO Diesel Engine Co., Fla., diesel engines to power the crawler's direct-current drive generators.

—Cummings Diesel Engine Co., Ind., auxiliary power units for lighting, etc.

—Riggs Engineering Co., Ky., fully automatic lubrication system for crawler's side frames and other chassis lubrication points.

—Schullen Steel Co., Mo., individual shoes for crawler's tracks.

—Crane Equipment Rental Co., Fla., heavy construction machinery for crawler-transporter erection and assembly.

● **Specs**—The crawler, 131 ft. long, 114 ft. wide and 20 ft. high, with cylinders extendable another 6 ft., can move unloaded at a maximum speed of 2 mph, loaded at 1 mph. When it is loaded, its cylinders will be extended about three feet.

Normal pressure of the hydraulic system is 2,780 psi; maximum pressure is 5,000 psi.

The d-c power system that powers the 16 traction motors consists of two diesel engines, each producing 2,750 horsepower, and four generators putting out 1,000 kw of power each. The a-c power system powers leveling, jacking steering, lighting, ventilating and electronic equipment and has two diesel engines of 1,065 horsepower each and two generators with a combined power output of 1,500 kw. The a-c auxiliary system powers the mobile launcher during transit with two generators that produce 150 kw each.

The crawler moves on four double-tracked crawlers, each 10 ft. high and 40 ft. long, along a specially compacted roadbed known as the crawlerway. When operational, it will be capable of handling curves of up to 500 ft. radius and a 5% incline while keeping its load within one-sixth of a degree of true vertical.

The crawler, tested so far only for a total of six miles, is to be operational in September. ■

ONE OF TWO crawler-transporters to be built to carry Saturn V/Apollo combination is shown in front of Vehicle Assembly Building under construction at Merritt Island.

Technical Countdown

SPACE MEDICINE

Otolith Function Researched

A flight experiment that will tell much about the functioning of the otolith in sensing gravitational force and its relation to disorientation and motion sickness is being assembled at NASA's Ames Research Center. The experiment will measure nerve output from single hair sensors of the otolith in an animal flown in an aircraft. An electrocardiogram will also be taken of the animal as the craft alternates between gravitational stress and zero-g.

TM Implants Successful

Case Institute of Technology has performed about 32 implantations of battery and RF-powered telemetering systems in rabbits, mice and rats. The units transmitted electrocardiogram and electromyogram up to four months with the RF-powered units, 10 days for the battery units. The transmitters were packaged with three protective layers; an epoxy layer for mechanical strength, a paraffin layer to seal out body fluids and a silastic layer to make the unit compatible with body tissue.

LIFE SUPPORT

Sweet Potato May Be Space Staple

Batelle Memorial Institute, working under an Air Force contract, has concluded that the sweet potato is well suited for space cabin use. Advantages are a high caloric count, high vitamin A, leaves are edible raw or cooked, short growing period of from 90 to 120 days, and efficiency in absorbing carbon dioxide and giving off oxygen. Tests are now being made in simulated space conditions, with later tests to include effects of weightlessness and efficiency in handling human wastes.

AF Studies Biochemical Control of CO_2

Biochemicals for use in advanced space cabin control of carbon dioxide are being explored at Wright Patterson AFB, Research and Technology Division, based upon the fact that living organisms handle CO_2 in a far more efficient manner than their man-made counterparts. One chemical under study is carbonic anhydrase, an enzyme that accelerates the hydration of carbon dioxide 1,000 times greater than normal hydration. Under slightly different conditions, when the same enzyme catalyzes the reverse is true. Air Force scientists see in it possibility for a new type of regenerable carbon dioxide removal agent.

Soft Suit Techniques Explored

An advanced soft spacesuit will be assembled by the U.S. Army Natick Laboratory for NASA's Advanced Research and Technology Office, incorporating new techniques being worked out on passive heat-removal systems. Garrett Corp. is investigating radiation cooling methods as substitutes for the gas-flow techniques used in *Gemini* and *Mercury* suits. Northrop Space Laboratories is conducting a study of sweat removal by a diffusion process and means for reducing temperature fluctuations resulting from external environmental changes. NASA also is looking at tighter fitting garments that would improve mobility.

ELECTRONICS

Monolithic Circuit Has 612 Devices

A 100-bit serial shift register with 612 active metal-oxide-silicon field-effect-transistor (MOS FET) devices is being produced in monolithic integrated circuit form by General Micro-electronics Inc. Applications include use as a fixed or variable delay line, a memory register, and a frequency divider. Frequency range extends from 50 kc to 1 mc. Power dissipation at 500 kc is 200 mw at a 25% duty cycle.

PROPULSION

Lunar Orbiter Engine Tested

The velocity-control system destined to guide the unmanned *Lunar Orbiter* spacecraft around the Moon passed its altitude-simulation development tests in The Boeing Co. Tulalip vacuum facility. The system uses a 100-lb.-thrust Marquardt restartable engine propelled by UDMH/hydrazine and nitrogen tetroxide. The powerplant will be gimbal-mounted and will provide mid-course correction. If necessary, the system can place the vehicle in orbit around the Moon. The orbiters will circle the Moon at an altitude of 28 miles, shooting pictures of likely *Apollo* landing sites.

MATERIALS

Acoustic Generator Installed at NAA

A 400,000-acoustic-watt generator developed and built by Northrop's Norair Div. is now in operation at North American Aviation's Aviation Acoustic Test Lab, Los Angeles Div. The unit will be used to test electronic systems designed for the *Apollo* program through creation of the sound pressure levels expected during a *Saturn V* launch. The generator gives NAA specialists the ability to achieve a combination of broadband random noise levels in excess of 163 decibels within the 9,000-cu.-ft. reverberant test cell. Sound pressures in excess of 181 decibels can be attained in the 3-sq.-ft. area of the 3 x 5 ft. progressive wave section of the test chamber where structural elements are tested.

SPACE SCIENCE

Astronomical Time Standard Error Observed

Computations of the Moon's orbit carried out for the past five years by scientists at International Business Machines Corp. indicate that currently used lunar ephemeris data contain a cyclic, fluctuating error of about 3/10 sec. in the astronomical time standard. The computations—which IBM scientists say provide a 100-fold increase in accuracy in describing lunar motion resulting from gravitational forces among Earth, Moon and Sun—also imply that discrepancies between observed and calculated motions relate to the distribution of mass within the Moon and motions could be caused by "a remarkable concentration of heavy material near the Moon's surface." Although this is not now a very widely held view, IBM's Dr. W. J. Eckert says it could be explained by accumulation of heavy meteoric material. Observation of the Moon's libration, he points out, indicates that it is rigid, unlike the Earth, so that such heavy material might remain near the surface.

ASTROLOG

Current Status of U.S. Missile and Space Programs

satellites and spacecraft

ADVANCED ORBITING SOLAR OBSERVATORY (NASA)

Republic, prime. DESCRIPTION: 1,250-lb. spacecraft to make detailed measurements of Sun's radiation; greater pointing accuracy (5 arc sec) than OSO; launch vehicle, THRUST AUGMENTED THOR-AGENA. STATUS: Development funding in FY '66 budget; two spacecraft to be launched in 1969, two in 1971.

APPLICATIONS TECHNOLOGY SATELLITE (NASA)

Hughes, prime; GE, gradient stabilization. DESCRIPTION: Five-satellite program to test communication and meteorological equipment at medium and synchronous orbit; test bed for gravity gradient communications and meteorological experiments; weight, 780 lbs.; launch vehicle, ATLAS-AGENA. STATUS: Development; first flight scheduled for late 1966.

APOLLO (NASA)

North American, Command & Service modules, systems integration; Grumman, Lunar Excursion Module (LEM); MIT, guidance development; AC Spark Plug, guidance prime; Collins Radio, telecommunications; Honeywell, stabilization & control; AiResearch, environmental control; Northrop-Ventura, parachute recovery; Lockheed Propulsion Co., escape tower rocket; Marquardt, reaction controls; IBM, realtime computer complex; Westinghouse, power conversion equipment. Lunar Excursion Module, prime, Grumman; descent engine, TRW Space Technology Laboratories; ascent engine, Bell Aerosystems; environmental control, Hamilton Standard; reaction control thruster, Marquardt; guidance, MIT; radar & communications instruments, RCA; TMC, telemetry, Radiation Inc.; fuel cell, Pratt & Whitney; external visual display, Forand Optical; GE, acceptance checkout reliability. DESCRIPTION: Three-man spacecraft for Earth-orbital, lunar-orbital and lunar-landing missions. Boosters: SATURN I and SATURN IB for Earth orbits; SATURN V for lunar rendezvous and landing missions; 3-modular spacecraft: Command Module weight, 5-1/2 tons; Service Module, 25 tons; Lunar Excursion Module, 15 tons; total weight, 95,000 lbs. STATUS: First of a series of unmanned orbital tests began with a boilerplate model launch on SA-7, Sept. 18, 1964; LITTLE JOE II unmanned abort test successful, Dec. 8, 1964; lunar orbits scheduled 1968; lunar landing by 1970; first manned orbital flight due last half of 1966.

ASSET (Air Force)

McDonnell Aircraft Corp., prime; Honeywell, gyros; Bell Labs, guidance. DESCRIPTION: Aerothermodynamic/elastic Structural Systems Environmental Tests for various materials combinations during re-entry; delta-shaped re-entry vehicle; two versions planned weighing 1,100 lbs. (4 vehicles) and 1,200 lbs. (2); length, 68.7 in.; span, 58.9 in. STATUS: Development. One AMR shot in September, 1963, successful although vehicle not recovered; third vehicle successfully launched and recovered, July 22, 1964; fourth launched Oct. 28, 1964; fifth successfully launched Dec. 8, 1964; sixth successfully launched Feb. 23, 1965, not recovered; end of program, unless recovered ASV-3 vehicle is re-flown. (See START).

ATHENA (Air Force)

Atlantic Research, prime; Honeywell, guidance. DESCRIPTION: 17,500-lb. four-stage re-entry vehicle, attains apogees from 600,000 to 1,000,000 ft.; last two stages drive vehicle and payload Earthward at near-ICBM velocities; major diameter, 32 in.; velocity package diameter, 28 in.; length, 51 ft. First-stage engine, Castor XM 33 (Thiokol); second stage, either X261 (Thiokol) or X259 (Naval Propellant Plant); third stage, 30KS 8000 (Aerojet); fourth stage, Ranger Retro BE3, Hercules. STATUS: Engaged in sub-scale testing of advanced re-entry concepts; 77 launches scheduled; 12 have been flown from Green River, Utah, site into White Sands Missile Range, N.M.; last flight Feb. 15.

BIOSATELLITE (NASA)

GE, prime. DESCRIPTION: 1,000-lb. satellites to test effects of space environment on plants, animals (primates) and other biological specimens; launch vehicle, THRUST-AUGMENTED DELTA. STATUS: Six flight models to be built; first flight in December, 1965; others to follow at three-month intervals; first experiments selected in February, 1965.

COMSAT CORP. SATELLITE PROGRAM

Studies being performed by Hughes, TRW with ITT, and AT&T and RCA as joint contractors. STUDIES: AT&T/RCA, 18 satellites, medium-altitude random orbit; STL/ITT, 12 satellites, medium-altitude, controlled orbit using gravity-gradient stabilization; Hughes 2nd-generation synchronous orbit system. STATUS: First satellites to be in orbit by mid-1966, with entire system operational by mid-1967.

DISCOVERER (Air Force Program 622A)

Lockheed, prime; GE, re-entry vehicle. DESCRIPTION: THOR-AGENA and ATLAS-AGENA launchings of stabilized satellites; main purpose is to test techniques and components for military space systems. STATUS: All data on program classified as part of DOD information policy; however, indications are that program has been cut back or ended as more economical vehicles have come into use.

EARLY BIRD (Comsat Corp.)

Hughes, prime. DESCRIPTION: Experimental modified syncom to be placed in 22,300-mi. stationary orbit and provide 240 two-way telephone channels between U.S. and Europe or simultaneous transmission of 22 or more telegraph messages; booster, THRUST-AUGMENTED DELTA. STATUS: Development; first satellite successfully launched into synchronous orbit, April 6. Second satellite may now be launched this year.

ECHO (NASA)

Langley Research Center, prime. DESCRIPTION: ECHO I, 135-ft. inflatable sphere in 700- to 805-mi. orbit; passive communication satellite; booster, THOR for ballistic tests; THOR-AGENA for orbital. STATUS: Program complete; ECHO I in orbit since Aug. 12, 1960; two ballistic shots in 1962 unsuccessful; ECHO II launched from Vandenberg Jan. 27, 1964; U.S.-USSR conducting series of cooperative experiments using ECHO.

FIRE, PROJECT (NASA)

Republic, re-entry package; Ling-Temco-Vought, velocity package; General Dynamics/Astronautics, launch vehicle and systems integration. DESCRIPTION: Re-entry probe to measure environmental heating at lunar return speeds (25,000 mph); launch vehicle, ATLAS D plus Antares II A-5 (re-entry booster). STATUS: R&D; first flight April, 1964, successful; second flight scheduled for May 4 will complete the project.

GEMINI (NASA)

McDonnell, prime; Rocketdyne, spacecraft propulsion; General Electric, fuel cell; IBM, guidance system integration and computer; Honeywell, guidance; Westinghouse, rendezvous radar; AiResearch, environment. DESCRIPTION: Bigger and heavier MERCURY-type capsule to carry two men for up to two weeks; TITAN II used as booster;

ATLAS-launched AGENA will be used for rendezvous missions; 15 spacecraft will be produced. STATUS: Development; 12 flights planned; will be used to determine feasibility of rendezvous for lunar mission and long-duration manned flight; first unmanned flight, April, 1964, successful; second unmanned orbital flight, January, 1965, successful; first manned flight successful March 23; three other flights scheduled for 1965; manned and rendezvous flights, 1966-67; AF participating in program, and will modify GEMINI capsules for MANNED ORBITING LABORATORY.

GEOS (NASA)

Applied Physics Laboratory, prime. DESCRIPTION: 350-lb. geodetic satellite (similar to ANNA) to carry flashing-light beacons, electronic beacons and optical and radar reflectors; launch vehicle, THOR-ABLE-STAR; 700-900-mi. orbit at a 59-degree inclination. STATUS: First flight planned in third quarter 1965. PAGEOS passive satellite developed by Langley Research Center will also be launched in the first half of 1966.

HYPERSONIC RESEARCH VEHICLE (AF, NASA)

No contractors announced. DESCRIPTION: Manned hypersonic spacecraft capable of Earth-to-orbit-and-return; turbofan, Mach 0-3; ramjet, Mach 3-8 or 10 (oxygen collected and liquefied during this cycle); Mach 8-10 orbital speeds, LH_2-LOX rocket. STATUS: Joint NASA-AF research program approved; NASA funding $5 million in FY '66; AF has advanced technology program in six pertinent areas (mostly engine developments) in FY '65. GE, Pratt & Whitney and Marquardt selected for conceptual and preliminary design of a research engine; engine flight test planned for early 1968.

ICBM ALARM (Formerly MIDAS) (Air Force Program 239A)

Lockheed, prime; Aerojet, IR detector system. DESCRIPTION: Early-warning random-orbit satellite; detect ICBM launchings by IR; two flights conducted in 1963 detected solid and liquid missile launches; satellites are launched piggy-back on various AF boosters. STATUS: Development; no decision on deployment; reportedly competing with over-the-horizon radar.

INTERPLANETARY MONITORING PLATFORM (NASA)

Goddard Space Flight Center, prime; Martin Co. developing nuclear power unit. DESCRIPTION: 131-181-lb. satellite launched into cis-lunar-space orbit with an apogee of more than 100,000 mi.; will measure radiation and solar flare hazards in advance of Project APOLLO; launched by DELTA and THRUST-AUGMENTED DELTA boosters from AMR. STATUS: IMP-I launched in December, 1963; IMP-II launched Oct. 3; five more satellites are planned, two to be placed in lunar orbit; later flights will use a nuclear power unit as replacement for solar cells; Designation, IMP-A is EXPLORER XVIII; IMP-B is EXPLORER XXI.

ISIS (Canada, U.S.)

Canadian Defense Research Board, satellite; NASA, launch vehicle. DESCRIPTION: Three-satellite follow-on program to ALOUETTE to continue ionospheric studies. STATUS: Design of ISIS A began in 1964 with launch planned in 1967; B and C to be launched in 1968, 1969; launch vehicle, THOR-AGENA.

LES (Air Force)

M. I. T. Lincoln Laboratory, prime; consulting support, TRW Space Technology Laboratories. DESCRIPTION: a series of Lincoln Experimental Satellites carried as Titan III-A and III-C "bonus" payloads to test military comsat devices and techniques. STATUS: First launch Feb. 11.

LUNAR LOGISTICS SYSTEM (NASA)

Studies have been conducted by Grumman, TRW/STL and Northrop. DESCRIPTION: Spacecraft to carry support payloads to the Moon. Two designs under study—LEM truck with 7,000-lb. payload and logistics spacecraft with 25,000 to 30,000-lb. payload; booster, SATURN V. STATUS: Program definition of the LEM truck planned in FY '66; program would cost about $1 billion; first step will be to extend lunar stay-time up to two weeks.

LUNAR ORBITER PHOTO CRAFT (NASA)

Boeing, prime; RCA, power and communications; Eastman Kodak, cameras; Marquardt, maneuvering engine. DESCRIPTION: 800-lb. spacecraft launched by ATLAS-AGENA will orbit Moon, taking pictures of lunar surface; radioactive and geodetic measurements will also be taken. STATUS: Five flights scheduled beginning in mid-1966.

MANNED ORBITING LABORATORY (Air Force)

Aerospace Corp., systems engineering & technical direction; study contracts awarded to Douglas, GE and Martin on the ORBITING SPACE STATION (OSS); also contracts for studies of selected subsystems. DESCRIPTION: Two-man spacecraft to establish military usefulness of man in space; booster, TITAN III-C; GEMINI-B capsule atop 10-ft.-dia., 14-ft.-long canister lab; total weight about 18,000 lbs.; orbit below 350 mi.; flights of 30 days in shirt-sleeve environment planned. STATUS: Sixty-day preliminary design studies totaling $400,000 each were awarded March 1 to four competing contractors, Boeing, Douglas, GE and Lockheed. $150 million in FY '66 funding requested; RFP's for program definition expected to be issued by mid-1965; unmanned Gemini/simulated canister launch, late 1966, using GT-2 capsule and Static Test Vehicle 4; manned Gemini/canister launch, 1968; rendezvous capability possible later. APOLLO hardware proposals being considered along with GEMINI in broadened MOL concept.

MARINER (NASA)

Jet Propulsion Laboratory, prime. DESCRIPTION: 570-lb. unmanned spacecraft for early interplanetary missions to vicinity of Mars and Venus; boosted by ATLAS-AGENA. STATUS: First scheduled Venus fly-by, August, 1962, unsuccessful after booster failure; second passed within 21,594 mi. of Venus, Dec. 14; two Mars fly-by spacecraft launched in November, 1964; first on Nov. 5 failed due to shroud malfunction; second on Nov. 28 successful, expected to pass Mars July 14; because of press of maintaining APOLLO schedules, NASA has dropped plans for 1966 Mars shot; agency will go directly to VOYAGER, a 7,000-11,000 lb. spacecraft for missions in 1970's, with a test flight in 1969.

MILITARY COMMUNICATIONS SATELLITE (Prog. 369) (AF, DCA, Army)

Aerospace Corp., systems engineering & technical direction; Philco, prime. DESCRIPTION: Multiple-launch, random, active repeater comsat; 24 satellites launched in groups of 8 satellites in 18,300-n.mi. polar orbits; weight about 100 lbs.; TITAN III-C booster. STATUS: Full-scale development as an "interim" system which is to be in operation in 1966. DCA has requested ideas from industry on a longer-lived Advanced Communication Satellite system; FY 1968 operational status planned.

NATIONAL ORBITING SPACE STATION (NASA, AF)

Many studies awarded. DESCRIPTION: Manned space station with orbital lifetime of one to five years for testing components and techniques in the space environment; weight ranges under study vary from 15,000-20,000 up to 200,000 lbs. STATUS: Decision not expected for one to four years; APOLLO-X, AF MANNED ORBITING LABORATORY, MANNED ORBITING RESEARCH LABORATORY and LARGE ORBITING RESEARCH LABORATORY being considered; program definition of APOLLO-X expected in FY '66; longer-life stations delayed until 1970's.

NIMBUS (NASA)

Goddard Space Flight Center, prime; GE, integration and testing; RCA, vidicon cameras. DESCRIPTION: 900-1,100-lb. second-generation weather satellite; Earth-stabilized polar orbiting; TV cameras and IR scanners in payload; THOR-AGENA B booster. STATUS: First launching successful Aug. 28, 1964; picture & IR quality good in spite of satellite's elliptical orbit; satellite quit transmitting Sept. 23; second scheduled in 1966, third in 1967 and fourth in 1968-69.

NUCLEAR DETECTION SATELLITES (Formerly Vela) (ARPA)

TRW Space Technology Laboratories, prime; Los Alamos Scientific Lab/Aerospace Corp., payload. DESCRIPTION: 20-sided, 485-lb. satellite for detection of nuclear explosions in space; 50,000-mi. orbit; booster, ATLAS-AGENA; launched in pairs. STATUS: First pair successfully launched in October, 1963; second pair successfully launched July 17, 1964; three pairs remain.

ORBITING ASTRONOMICAL OBSERVATORY (NASA)

Grumman, prime; Westinghouse, ground station, components; GE, stabilization and control; Kollsman, star trackers; IBM, data processor and storage; Hughes and Avco, communications equipment. DESCRIPTION: 3,600-lb. orbiting astronomical satellite to study ultraviolet spectrum from approximately 1,200 Å to 4,000 Å; four major experiments selected; one piggyback; booster, ATLAS-AGENA D. STATUS: Three flights beginning in late 1965.

ORBITING GEOPHYSICAL OBSERVATORY (NASA)

TRW Space Technology Laboratories, prime; DESCRIPTION: 1,000-lb. satellite with instruments for geophysical measurements; polar (POGO) and eccentric (EGO) shots planned; can carry more than 20 experiments; ATLAS-AGENA B, THRUST-AUGMENTED THOR, booster; STATUS: First launch Sept. 4, 1964, partially successful; 16 of 20 experiments working; five other launches planned, with next flight scheduled for second half of 1965.

ORBITING SOLAR OBSERVATORY (NASA)

Ball Brothers, prime. DESCRIPTION: OSO 1,458-lb. orbiting solar observatory; OSO II, 535-lbs.; booster, DELTA; S-16 early version; S-17 and S-57 advanced versions. STATUS: First flight March 7, 1962, highly successful; first flight for S-17 planned for second quarter 1964 delayed until 1965; six more flights planned.

PEGASUS (NASA)

Fairchild Hiller, prime. DESCRIPTION: 3,400-lb. meteoroid-detection satellite employing two 50 x 15 ft. extendable detector wings; Earth orbit 300 to 800 mi.; booster, SATURN I. STATUS: Development; will measure size, energy and frequency of meteoroids to evaluate hazards of impact with manned spacecraft; first launch successful in February; formerly known as METEOROID DETECTION SATELLITE; two more satellites will be launched as part of SATURN I development program. Cislunar PEGASUS may be launched in 1968-69.

PIONEER (NASA)

TRW Space Technology Laboratories. DESCRIPTION: 130-lb. spin-stabilized solar probe; augmented DELTA launch vehicle; cylindrical; covered with 10,000 solar cells; four outrigger booms for stabilization; five experiments, 60 to 90-million-mi. communication capability. STATUS: Seven launches in program; mid-1965 launch schedule set; orbits range from 0.8 to 1.2 au for 6-mo. lifetime; EXTENDED PIONEER under study.

PROJECT SCANNER (NASA)

Honeywell, fabrication and integration; Baird-Atomic, star-mapper telescope; Santa Barbara Research Center, dual radiometers. DESCRIPTION: Unmanned scientific satellite to measure natural radiation

gradients of Earth's horizon to determine utility of spacecraft horizon sensors. STATUS: Flights to begin in 1965.

RADIO ASTRONOMY EXPLORER (NASA)

Goddard, prime for first two spacecraft with industry to build remaining four. DESCRIPTION: 270-lb. satellite which will have four 750-ft. extendable antennas to pinpoint radio emissions in space. STATUS: Hardware funding approved in FY '65 & '66 budgets, with first launch by a THRUST-AUGMENTED DELTA in 1967.

RANGER (NASA)

JPL, prime; Hercules, retro-rocket; Northrop, support contractor; RCA, TV system. DESCRIPTION: Before impact, TV cameras take pictures of lunar surface; ATLAS-AGENA B booster. STATUS: RANGER VI launched Jan. 30, 1964, TV system failed; RANGER VII launched July 28, 1964, and impacted Moon after transmitting 4,316 pictures back to Earth; RANGER VIII launched Feb. 17, 1965, impacted Moon Feb. 20, after transmitting more than 7,000 pictures; RANGER IX launched March 21; struck Moon March 24 after transmitting 5,814 photos; program now complete.

RELAY (NASA)

TRW Space Technology Laboratories, project coordination and systems planning; RCA, prime. DESCRIPTION: 172-lb. spin-stabilized wideband 800 to 4,600-mi.-orbit active repeater experimental communications satellite; booster, DELTA; STATUS: Britain, France, Brazil and Germany building ground stations; first launch, Dec. 13, 1962; RELAY II launched Jan. 21, 1964; program completed.

SAMOS (Air Force Program 720A)

Lockheed, prime; photo intelligence equipment, Eastman Kodak; capsules, GE; parachute and guidance recovery equipment, Avco and Northrop Ventura. DESCRIPTION: Reconnaissance satellite; formerly SENTRY; R&D model weighs 4,100 lbs. with E-5 capsule (3,000 lbs. with E-6); booster, ATLAS-AGENA; 100-300-mi. circular polar orbit. STATUS: Operational; advanced SAMOS under development; FERRET version used for electronic intelligence and communications eavesdropping.

SATAR (Air Force)

General Dynamics, prime. DESCRIPTION: 300-lb. scientific satellite pod mounted on side of ATLAS booster; length, 55 in.; diameter 27 in.; 200-lb. payload; orbits vary from 500 to 2,000 n. mi.; as re-entry vehicle, gains speeds up to 30,000 fps; guidance, strap-down system with three orthogonally mounted gyros; unstabilized when in orbit. STATUS: Development; seven vehicles being built under present contract; pods of SATAR type have been flown on 44 missions.

SATELLITE INSPECTOR (Air Force PROGRAM 706)

No contractors announced. DESCRIPTION: Satellite inspection system consisting of a spacecraft capable of co-orbital inspection of non-cooperative satellites. STATUS: Re-oriented from unmanned vehicle to manned satellite using GEMINI; Conceptual preliminary design studies under way; early GEMINI flights expected to provide important inputs; $2 million in FY '65 budget.

SECOR (Army)

Cubic Corp., prime, transponder and ground stations; ITT Labs, satellite vehicle. DESCRIPTION: 40-lb. geodetic satellite; rectilinear, measuring 9 x 11 x 14 in.; can be carried piggyback on a variety of boosters; frequency, 162-324 mc for geodetic measurements; 54-216 mc for refraction studies. STATUS: Operational SECOR vehicles 1, 3 and 2 now in orbit, launched in order of mention, the latter two in March; an expanded program at altitudes of 1,800 mi. is being considered.

SERT (NASA)

RCA, prime. DESCRIPTION: Spinning ballistic test vehicle carrying two electric-propulsion engines for environmental tests. STATUS: First flight July 20, 1964, from Wallops Island, Va., carried a Lewis electron bombardment engine and a Hughes contact ionization engine; the Lewis engine worked well while Hughes engine produced no thrust; follow-on flights cancelled since SERT I proved neutralization of an ion beam in space; SERT III now under study.

START (Air Force)

Award in only one of an expected 10-14 areas has been announced; Martin Co. for work on a vehicle related to the in-house SLV-5; Aerospace Corp., general systems engineering and technical direction. DESCRIPTION: An experimental program, much broader than ASSET, to explore the materials, structures, flight regimes and other areas related to glide atmospheric entry. STATUS: Program package is still being assembled.

SURVEYOR (NASA)

Hughes, prime; Martin, SNAP device. DESCRIPTION: 2,150-lb. spacecraft for soft-landing 100-300 lbs. of instruments on Moon; nine 2,500-lb. spacecraft are also planned; booster, ATLAS-CENTAUR; SNAP nuclear generator optional. STATUS: First Moon flights early 1966; five soft-landing vehicles planned in Block I series; 17 flights scheduled.

SYNCOM (NASA)

Hughes, prime. DESCRIPTION: 24-hr.-orbit instantaneous narrow-band, active-repeater communications satellite; 28 in. in dia. and weighs about 63 lbs.; booster, DELTA; capable of accommodating one full duplex radio telephone channel. STATUS: First launch failed, Feb. 14, 1963; satellite believed to be in orbit but contact lost; SYNCOM II launched July 26, 1963, completely successful; third launch Aug. 19, 1964, successful; satellite, positioned in stationary orbit over Pacific, relayed 1964 Olympic Games to U.S. from Japan; program now complete. DOD has taken over satellites for military traffic.

SMS (Synchronous Meteorological Satellite) (NASA)

Republic, RCA Astro-Electronics, Hughes, study contracts. DESCRIPTION: 24-hr. weather satellite, Earth-stabilized; TV cameras with variable focus; may use SNAP-50 for power; booster may be ATLAS-AGENA or -CENTAUR. STATUS: Studies to continue; development funds not included in FY '66 budget; ATS and TIROS expected to provide major inputs to the program.

TELSTAR (AT&T, NASA)

Bell Telephone Laboratories, management for AT&T. DESCRIPTION: 170-lb. active repeater experimental industry communication satellite; DELTA booster. STATUS: Development; first launch July 10, 1962, highly successful; second launch May 7, 1963, also successful; program now complete.

TIROS (NASA, Weather Bureau)

RCA, prime. DESCRIPTION: 285-lb. meteorological satellite; TV pictures of cloud cover; IR sensors to gather heat balance data; one TIROS to be tested for effectiveness in highly elliptical orbit (300-3,000 mi.) STATUS: R&D; nine satellites launched; all successful; five more launches planned with TIROS wheel configuration (Earth-stabilized) to serve as an interim National Operational System.

TRANSIT (NAVY)

Applied Physics Laboratory, prime; Martin, SNAP device; Westinghouse, shipboard satellite signal receivers. DESCRIPTION: Navigational satellite; R&D model over 250 lbs.; operational, 50 to 100 lbs.; operational system; four satellites in random, near-circular 600-mi. orbits; SNAP nuclear generator; ABLESTAR, SCOUT booster. STATUS: Four-satellite system operational since July, 1964; system established for use by POLARIS subs and surface ships; two nuclear-powered (SNAP-9A) satellites launched in 1963; NASA exploring feasibility of commercial system.

TRS (Air Force)

TRW/STL. DESCRIPTION: 3-lb. scientific satellite to measure radiation; four-sided, measuring 9 in. on a side. STATUS: Operational; first launched piggyback on DOD payload Oct. 17, 1963.

VOYAGER (NASA)

Seven firms competing for phase I study contracts. DESCRIPTION: Unmanned 7,000-11,000-lb. MARINER follow-on spacecraft bus/lander to orbit Mars and eject a capsule to the surface. STATUS: Development expected to begin in early 1966; program definition funded in FY '66; launches in 1971-73 period; spacecraft to be launched by SATURN IB/CENTAUR, and will be used to explore other planets through 1970's.

X-15 (NASA, AF, NAVY)

North American, prime; Thiokol, propulsion; Sperry Gyroscope, inertial flight data system; Honeywell, adaptive flight control electronics. DESCRIPTION: Manned rocket plane capable of 4,000-mph-plus flight at edge of space; single rocket engine develops 57,000 lbs. thrust. STATUS: Powered flights in progress; unofficial records set—altitude 354,200 ft. and speed 4,104 mph; hypersonic propulsion research program should run through 1968; more than 100 flights have been made; ramjet (X-15A2) flights scheduled for 1968.

space vehicles

ABLESTAR (Air Force)

Space-General, prime; Aerojet, propulsion; Space-General/Bell Telephone, guidance. DESCRIPTION: 2,000-lb. upper stage; 9.5 ft. long; 55 in. dia.; radio command guidance; propellants, UDMH/IRFNA; restart capability. STATUS: Used in TRANSIT and other military programs; THOR booster.

ATLAS-AGENA D (Air Force)

General Dynamics/Astronautics (ATLAS); Lockheed (AGENA); TRW/STL, AGENA B; Honeywell, inertial reference. DESCRIPTION: 275,000-lb. booster; payload capability, 5,000 lbs., in 345-mi. orbit, 750 lbs. to escape, length, 102 ft.; base diameter, 10 ft.; liquid propulsion; modified ATLAS D with 360,000-lb. thrust; AGENA B with 15,000-lb.

thrust; restart capability. STATUS: Operational; used in RANGER, DISCOVERER, MILITARY COMSAT, MARINER, LUNAR ORBITER, OAO, SAMOS and other programs. ATLAS Standard Launch Vehicle developed for AF space programs; ATLAS launches from WTR being used in conjunction with ATHENA launches at Green River, Utah, in an effort to develop scaling laws for re-entry bodies (Advanced Ballistic Re-entry Systems program).

AGENA D (Air Force)

Lockheed, prime; Honeywell, guidance; Bell, propulsion. DESCRIPTION: 1,700-lb. upper stage; 25 ft. long; 5 ft. dia.; all-inertial guidance; propellants, UDMH/IRFNA; multiple re-start capability; ATLAS, THOR and THOR-augmented boosters. STATUS: Used in DISCOVERER, SAMOS and other military programs as well as a variety of NASA programs; e.g., MARINER, RANGER, OAO and OGO.

CENTAUR (NASA)

Lewis, program management; General Dynamics/Astronautics, prime; Pratt & Whitney, propulsion; Honeywell, guidance. DESCRIPTION: High-energy upper stage using a pair of RL-10 LOX/liquid hydrogen engines; 30,000 lbs. total thrust; 30 ft. long; 10 ft. dia.; ATLAS D booster; capable of orbiting 8,500 lbs.; 2,300 lbs. to escape; 1,300 lbs. on planetary flights. STATUS: Development; first flight failed; second launch Nov. 27, 1963, successful; third, June 20, 1964, partially successful; fourth flight Dec. 11, 1964, successful; Dec. 11; fifth flight Mar. 2 failed when ATLAS-CENTAUR exploded on pad; three more flights set for 1965; vehicle to become operational in 1965.

DELTA (NASA)

Douglas, prime; Bell Telephone Labs, guidance; Rocketdyne/Aerojet/Allegany Ballistics Laboratory, propulsion. DESCRIPTION: Successor to THOR-ABLE; upper-stage guidance; three-stage vehicle; 800-lb. payload capability in 100-mi. orbit; THRUST-AUGMENTED DELTA payload capability 1,500-plus lbs. in 100-mi. orbit; THOR missile comprises first stage. STATUS: Launch vehicle for TIROS, EXPLORER, OSO, BIOS, ECHO; TAD used for SYNCOM & PIONEER; 26 previously on order augmented by AF order for 21 more for NASA; THRUST-AUGMENTED DELTA with three solid motor strap-ons also being used.

LITTLE JOE II (NASA)

General Dynamics/Convair, prime. DESCRIPTION: Solid-propelled vehicle with 800,000-lb. thrust; launch vehicles for APOLLO suborbital flights. STATUS: Three launches Aug. 28, 1963, May 13, 1964, Dec. 8, 1964, successful; six vehicles ordered thus far.

POST-SATURN V LAUNCH VEHICLE (NASA)

Under study. DESCRIPTION: No firm concept but will be significant improvement over SATURN V (20-30 million-lb.-thrust first-stage large solid motors, and nuclear upper stage under consideration). STATUS: Study to determine characteristics; operational target date post-1975.

ROVER (NASA, AEC)

Los Alamos Scientific Labs, ROVER prime; Aerojet, NERVA prime; Westinghouse, propulsion. DESCRIPTION: First nuclear rocket; tests of Kiwi, prototype of NERVA engine, under way. STATUS: Kiwi tests completed this year; NERVA tests highly successful; full systems tests of engine now set for fall, 1965—12 months ahead of schedule; development of Phoebus reactor initiated; no flight test program funded at present.

SATURN I (NASA)

Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler Corp.; S-IV, Douglas. DESCRIPTION: Two-stage vehicle for early boilerplate tests of APOLLO and PEGASUS; first stage: eight Rocketdyne H-1 engines; second stage: six Pratt & Whitney RL-10-A3 engines; 22,500 lbs. into 345-mi. orbit. STATUS: Four flight tests of first stage successful; all flights with inert upper stage; first flight with live upper stage successfully launched Jan. 27, putting 37,700 lbs. in low Earth orbit; SA-6 May 28, 1964 and SA-7 Sept. 18, 1964, also successful; SA-9 on Feb. 16 put PEGASUS satellite into orbit; two more R&D flights planned to complete development effort.

SATURN IB (NASA)

Systems engineering, assembly and guidance, Marshall Center; S-1 stage, Chrysler; S-IVB stage, Douglas. DESCRIPTION: S-1, eight H-1 engines; S-IVB, one J-2 engine; payload capability, 35,000 lbs. in 105-mi. orbit. STATUS: Development; first flight in 1966; boost APOLLO spacecraft boilerplate models, including lunar landing vehicle; first manned flight in APOLLO program set for late 1966; advanced version able to orbit 30 tons under consideration. Booster for VOYAGER with CENTAUR upper stage

SATURN V (ADVANCED SATURN) (NASA)

Systems engineering, assembly and guidance, Marshall Space Flight Center; S-IC stage, Boeing; S-II, North American; S-IVB, Douglas; F-1 engine, North American; J-2, North American. DESCRIPTION: S-IC, five F-1 engines; S-II, five J-2 engines; S-IVB, J2 engine; 140-ton payload in 105-mi. orbit; 95,000 lbs. to escape velocity; 30 tons for planetary missions. STATUS: R&D; first flight scheduled for 1967; prime booster for APOLLO missions; will be used to boost orbiting space station.

SCOUT (NASA)

LTV Aerospace Corp., prime; Honeywell, guidance; Aerojet/Thiokol/Allegany Ballistic Laboratory, propulsion. DESCRIPTION: Solid propulsion four-stage satellite launcher; 72 ft. long; 3.3 ft. dia.; 240-lb. payload in 345-mi. orbit; 80 lbs. to escape. STATUS: Operational; used by NASA for EXPLORER and other small payloads; also procured by NASA for Air Force as BLUE SCOUT; NASA has ordered 23 more boosters.

THOR-ABLE STAR (Air Force)

Douglas, prime; Bell Telephone labs, guidance; Rocketdyne, first-stage propulsion; Space-General, second; DESCRIPTION: Two-stage vehicle with 181,900 lbs. total thrust; performance, 900 lbs. in 100-n.-mi. orbit; length, 55.9 ft., diameter, 8 ft., weight, 118,200 lbs., height, 79 ft.; guidance, radio command; STATUS: Operational; used in TRANSIT, GEOS and other military programs.

THOR-AGENA D (Air Force and NASA)

No prime; Douglas, THOR frame; Lockheed, AGENA D; Rocketdyne, propulsion. DESCRIPTION: Liquid-propulsion vehicle to put 1,600-lb. payload in 300-mi. orbit; length, 76 ft.; diameter, 8 ft.; launch weight, 123,000 lbs.; 172,000 lbs. thrust; THOR, radio guidance, AGENA, all-inertial. STATUS: Operational; used in AF space program, TELSTAR, Topside Sounder and other NASA programs; NASA has 11 launches scheduled.

THRUST-AUGMENTED DELTA (NASA)

Douglas, prime; Thiokol, solid propulsion. DESCRIPTION: DELTA launch vehicle with three strap-on solids; performance, 1,000 lbs. to Earth orbit; 150 lbs. to escape; propulsion, three XM-33 solid motors producing 55,000 lbs. thrust each. STATUS: Development; to be used for BIOSATELLITE, PIONEER, SYNCOM, TIROS, COMSAT programs; initial flight Aug. 19, 1964, successful.

THRUST-AUGMENTED THOR (Air Force/NASA)

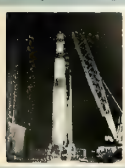
No prime; Rocketdyne and Thiokol, propulsion. DESCRIPTION: THOR-AGENA with 3 strap-on solids; THOR liquid propulsion, 172,000 lbs. of thrust; each strap-on, 55,000 lbs. thrust; performance, 2,500 lbs. in 100-n.mi. orbit. STATUS: Operational; used for NIMBUS, POGO and other payloads too heavy for THOR, but not heavy enough for ATLAS.

TITAN II (GLV) (NASA)

Aerospace Corp., systems engineering & technical direction; Martin, prime. DESCRIPTION: Manned space booster; Essentially Titan II with addition of redundant electrical power and flight control systems, malfunction detection system and radio command guidance. STATUS: Development; GT-2 (unmanned version) launched Jan. 19; GT-3 successful on March 23.

TITAN III (Air Force Program 624A)

Aerospace Corp., systems engineering & technical direction; Martin, systems integration; United Technology, large solid boosters; Martin, TITAN II portion; Aerojet-General, liquid engines (Transtage); Martin, standardized upper stage; AC Spark Plug, guidance. DESCRIPTION: Quick-reaction vehicle for military space missions; will be used to boost MOL/GEMINI B; Zero stage, two 120-in. solid motors; first and second stages, TITAN II (storable propellants); third-stage standardized vehicle to be developed; modified TITAN II guidance; payload, 25,000 lbs. in 100-n.mi. orbit, 2,100 to 22,300-mi. orbit; 5,000 lbs. to escape STATUS: Development; first flight Sept. 1, 1964 (T-IIIA) achieved primary and secondary objectives, but failed to achieve orbit; second flight (T-IIIA) successful Dec. 10, 1964; third flight successful, Feb. 11; Transtage maneuvers included 3 starts, orbited LES-1 communications satellite; 17 development flights planned; five TITAN II core vehicles (A version), 12 full TITAN III's (C version); eight other satellite payloads have been approved for launch during flight test program; development stretchout moves operational date to June, 1967; an unmanned rated version—TITAN III-X—being studied as more cost/effective booster for satellite launches; uses first two TITAN III-A stages and an AGENA upper stage; first launch, mid-1966. Twenty-four vehicles planned as initial buy.



missiles

ADVANCED SURFACE MISSILE SYSTEM (Navy)

Raytheon, Boeing, Sperry Rand, General Electric, Westinghouse, RCA & Hughes, pre-program definition contracts. DESCRIPTION: Fleet air-defense weapon for the 1970 time period; to have capability

against aircraft and certain types of air-to-surface missiles; will replace the 3-T systems currently in the fleet. STATUS: Pre-program definition; program definition planned in mid-1965 and development contract by 1966; $12 million requested in FY 1966 to complete PDP phase.

ALFA (RUR-4) (Navy)

Navy, prime; Avco, frame; Naval Propellant Plant, propulsion. DESCRIPTION: ASW, surface-to-underwater; weight, 500 lbs.; solid propulsion; H.E. depth charge; range, 1,000 yds.; guidance, free-flight. STATUS: Operational; deployed on destroyers and cruisers; being replaced by ASROC.

ANTI-SATELLITE WEAPON (Army/Air Force)

Boeing, AF program; Hughes, terminal guidance (IR), AF program; Douglas, THOR and ZEUS vehicles and support services; A. D. Little, Operations Analysis. DESCRIPTION: Consists of both NIKE-ZEUS and THOR-AGENA w/terminal stage programs; intercepts have been accomplished at "hundreds of miles," according to Secretary McNamara. STATUS: Operational according to DOD; however, major portions of the AF program are uncompleted at the Johnston Island test site. RFPs for a follow-on were to have been issued in December, 1964.

ARM I (Navy)

No contractor announced. DESCRIPTION: Longer-range, smaller anti-radiation missile than SHRIKE for armament of F-111B and A-7A aircraft. STATUS: Advanced development.

ASROC (RUR-5A) (Navy)

Honeywell, prime; Sangamo Electric, sonar; GE, torpedo; Librascope-General Precision, fire control. DESCRIPTION: ASW, surface-to-underwater; weight, 1,000 lbs.; solid propulsion; warhead, nuclear or conventional torpedo; range between 1,800 yds. and 8 mi.; guidance, unguided. STATUS: Operational on DE, DD, DLG, & heavy cruisers; one "live" weapon fired in 1962 Pacific nuclear tests; extended range version in pre-program definition phase; version adaptable to TERRIER launchers being developed. FY 1966 procurement to complete Navy's stock needs.

ASTOR (Mk-45) (Navy)

Westinghouse, prime. DESCRIPTION: Mark 45 ASW, underwater-to-underwater torpedo; weight, over 2,000 lbs.; solid propulsion; warhead, nuclear; range, about 11 n.mi; guidance, wire. STATUS: In production; deployed on hunter-killer submarines.

BOMARC A (AIM-10A) (Air Force)

Boeing, prime; IBM/Westinghouse, guidance; Aerojet/Marquardt, propulsion. DESCRIPTION: Surface-to-air interceptor; weight, 15,000 lbs.; liquid booster/ramjet propulsion; warhead, nuclear; range, 200 n.mi.; guidance, command via SAGE; speed, Mach 2.5; ceiling, over 68,000 ft. STATUS: All A missiles at five bases operational in northeastern U.S. to be phased out by the end of FY 1965; production completed; costs $20 million per year to operate system.

BOMARC B (AIM-10B) (Air Force)

Boeing, prime; General Precision Aerospace/Westinghouse/IBM, guidance; Thiokol/Marquardt, propulsion. DESCRIPTION: Surface-to-air; weight, 16,000 lbs.; solid booster/ramjet propulsion; warhead, nuclear; range, more than 400 n.mi.; guidance, command via SAGE; speed, Mach 2.7. STATUS: Three bases operational; production completed; the 188 B models will be distributed among the eight bases after the A model is phased out.

BULLPUP (AGM-12 B & C) (Navy-Air Force)

Martin, systems cognizance; Maxson Electronics Co., production; AMF, liquid engine; Thiokol, solid propulsion; Naval Propellant Plant, solid propulsion (motor loading). DESCRIPTION: Air-to-surface; range, 3-6 mi.; guidance (visual reference), radio-link command. BULLPUP A: Solid propulsion; warhead, 250-lb. H.E. BULLPUP B: pre-packaged liquid motor; warhead, 1,000-lb. H.E. STATUS: BULLPUP A deployed with Atlantic and Pacific Fleets; operational with U.S. Air Force & NATO units; training version (ATM-12) being procured by both services; being produced in Europe for NATO. Planned procurement of BULLPUP B cancelled in FY 1966.

CHAPARRAL (Army)

A surface-to-air adaptation of the Navy's air-to-air SIDEWINDER. Mounted on vehicles, in a 4- or 6-missile configuration. Philco's Aeronutronic Div. awarded contract for design, development, fabrication and testing of a CHAPARRAL system. CHAPARRAL will be an interim solution to forward-area air defense. (See: SIDEWINDER.)

CLOSE-SUPPORT ASSAULT WEAPON (Navy)

Navy Bureau of Weapons and Johns Hopkins Applied Physics Lab, prime; United Aircraft Norden Div., guidance. DESCRIPTION: Ship-to-shore; outside dimensions compatible with TERRIER shipboard installations; solid propulsion; warhead, high explosive, range, 30 mi. minimum; guidance, inertial and terminal. STATUS: Carried as a line item in FY '66 budget; gyro packages for flight test delivered by Norden; funding dependent on results of guidance system flight tests at WSMR aboard SERGEANT missiles.

CONDOR (AGM-53) (Navy)

In-house project, Naval Ordnance Test Station; North American Aviation, Columbus Div. and Northrup Norair Div. awarded PDP studies. DESCRIPTION: Air-to-surface; configuration classified, Range, 40 mi. STATUS: Development; intended for use with Navy version of F-111 and on A-6 Aircraft.

DAVY CROCKETT (M-388) (Army)

In-house project directed by Army Weapons Command at Rock Island, Ill. DESCRIPTION: Surface-to-surface; solid propulsion, bazooka-launched; warhead, sub-kiloton nuclear; guidance, free flight; two launchers — vehicle-mounted or carried by two men. STATUS: Operational in Europe; $13 million provided in FY '64 budget; three per ROAD battalion; seen as defensive rather than offensive weapon to prevent overrun of Europe.

ENTAC (MGM-32) (Army)

Nord Aviation, prime. DESCRIPTION: Anti-tank; weight, 37 lbs. with launcher; solid propulsion; warhead, shaped-charge H.E.; range, 6,600 ft.; guidance, wire-guided; man-portable. STATUS: Operational; procurement complete; will be replaced by TOW.

FALCON (AIM-4 A, C, E, F/26A/47A) (Air Force)

Hughes, prime; Hughes, guidance; Thiokol, AIM-4/26 propulsion; Lockheed Propulsion, AIM-47 propulsion. DESCRIPTION: Air-to-air; weight (AIM-4/47), more than 100 lbs. — (AIM-26), more than 200 lbs.; range 5 n.mi.; supersonic; solid propulsion; warhead, H.E. (except for AIM-26B, which carries nuclear warhead); AIM-4A, and 4E, active radar homing guidance; AIM-4C, and 4F, IR homing; AIM-26 model has nuclear warhead and hybrid IR radar homing. STATUS: Operational buy-out of 4E, 4F and 26 in FY '62; AIM-47 is the armament for YF-12A (A-11); several versions operational on F-101, F-102 and F-106.

GENIE (AIR-2A) (Air Force)

Douglas, prime; Aerojet-General, propulsion. DESCRIPTION: Air-to-air; weight 800 lbs.; unguided; solid propulsion; warhead, nuclear; range, 6 n.mi.; guidance, free flight; supersonic; proximity fuzing. STATUS: Procurement complete; operational on F-101B and F-106; improved version cancelled. Launcher being developed by McDonnell for adaptation to F-4 aircraft.

HAWK (MIM-23A) (Army)

Raytheon, prime; Raytheon, guidance; Aerojet-General, propulsion. DESCRIPTION: Surface-to-air; weight, 1,275 lbs.; solid propulsion; warhead, H.E.; range, 22 mi.; guidance, semiactive radar homing; 100-45,000-ft. ceiling; provides defense against medium and low-flying aircraft and cruise-type missiles. STATUS: Operational, deployed in Europe, Panama, Okinawa, South Viet Nam, U.S. (13 battalions); bought by Sweden and Israel; R&D being conducted to adapt selected HAWK units to an anti-tactical ballistic missile; NATO producing; Japan also plans buy; $34 million requested for equipment and $8 million for spares in FY '66; no further procurement in FY '66; $11 million improvement program aimed at limited anti-missile capability.

HIBEX (ARPA/Army)

Boeing, prime; Hercules and Aerojet, propulsion. DESCRIPTION: Experimental program in high-energy propellants; cone-shaped missile; performance classified; solid propulsion. STATUS: Development; accelerations of 800 to 1,000 g's goal; static test of motor successful, Nov. 1964; flight test program of 10 vehicles being conducted at WSMR; first successful flight test, Feb. '65, at WSMR.

HONEST JOHN (MGR-1) (Army)

Douglas/Emerson Electric, prime; Hercules, propulsion. DESCRIPTION: Surface-to-surface; weight, 5,900 lbs.; single-stage solid propulsion; warhead, nuclear; range, 12 mi. (M-31), 20 mi. (M-50); unguided. STATUS: Operational; M-50 being deployed in Europe; to be replaced by LANCE; procurement complete.

HORNET (ZAGM-64A) (Air Force)

(Formerly known as ATGAR). Concept based on North American Aviation Columbus Div. unsolicited proposal, funded by AF. DESCRIPTION: Air-launched, anti-tank weapon, electro-optical guidance. STATUS: pre-development, AF procuring missiles for test at Eglin AFB.

HOUND DOG (AGM-28) (Air Force)

North American, prime; Autonetics, guidance; Pratt & Whitney, propulsion. DESCRIPTION: Air-breathing air-to-surface standoff missile; weight, 9,600 lbs.; turbojet propulsion; warhead, nuclear; range, about 600 n.mi.; guidance, all-inertial; ceiling in excess of 50,000 ft.; Mach 2+. STATUS: Operational; to be launched from B-52G intercontinental bombers; procurement complete.

LANCE (XMGM-52) (Army)

LTV Aerospace, prime; Systron-Donner, guidance. DESCRIPTION: Highly mobile general-purpose missile; very light weight; pre-packaged storable liquid propellant; warhead, nuclear and H.E.; range, 3-30 mi.; guidance, Autonet inertial, one missile per launcher. STATUS: Large-scale development. Second successful flight test in Mar. '65; both initial flight tests from fixed site, not operational launcher; no FY 1966 production planned; eventually will replace HONEST JOHN and LACROSSE and perhaps LITTLE JOHN; division support weapon; to use multi-system test equipment.

LITTLE JOHN (MGR-3) (Army)

Emersion Electric, prime; Hercules Powder, propulsion. DESCRIPTION: Surface-to-surface; weight, 800 lbs.; solid propulsion; warhead, nuclear; range, 10 mi.; unguided; supplements medium and heavy artillery in airborne divisions and air-transportable commands. STATUS: Two battalions activated in 1961; each equipped with four launchers; air- and helicopter-transportable; may be replaced by LANCE.

M72 (Army)

Hesse/Eastern Div., Flightex Fabrics, prime. DESCRIPTION: Light anti-tank rocket; weight, 4.5 lbs.; solid propulsion; warhead, H.E.; range, 500 yds.; guidance, free flight; carrier tube launcher; earlier called LAW. STATUS: Operational.

MACE (MGM-13A, CGM-13B) (Air Force)

Martin, prime; Goodyear/AC Spark Plug, guidance, Thiokol/Allison, propulsion. DESCRIPTION: Air-breathing surface-to-surface; weight, 18,000 lbs.; turbojet and solid propulsion; warhead, nuclear and H.E.; range, over 650 n.mi. (Model A), over 1,200 n.mi. (Model B); guidance, map-matching (A), Inertial (B). STATUS: Five MACE-A and one MACE-B squadrons (in hard sites) deployed in Europe; two MACE-B squadrons on Okinawa in hard sites.

MAULER (MIN-46) (Army)

GD/Pomona, prime; Lockheed, propulsion; deHavilland, IR acquisition study; Raytheon, radar; Burroughs, computer; FMC, carrier vehicle. DESCRIPTION: Surface-to-air; weight, 120 lbs.; solid propulsion; warhead, conventional H.E.; guidance, homing; highly mobile antiaircraft missile; tracked vehicle; 9 missiles per launcher. STATUS: Development; suffering serious packaging problems: Army postponing more advanced models until after feasibility validation program has determined if system can be saved; no FY '66 funding.

MAW (Army)

McDonnell Aircraft Co. and Army Missile Command, development of competitive approaches to Medium Anti-Tank/Assault Weapon requirement; Ford Instrument Co., gyro package for Army version. DESCRIPTION: Surface-to-surface; solid propellant; range, 500-1,500 yds.; shoulder-fired; McDonnell version wire-guided; Army version two-degree-of-freedom, free rotor gyro. STATUS: Exploratory Development; competitive approaches to be fired off against each other in Summer, 1965, using a ZUNI test vehicle, and the best allowed to proceed into full-scale development.

MINUTEMAN (LGM-30) (Air Force)

TRW Space Technology Laboratories, systems engineering and technical direction; Boeing, major contractor; Autonetics, guidance, Thiokil, first-stage propulsion; Aeroject, second-stage propulsion; Hercules, third-stage propulsion; Avco, re-entry vehicle; GE, MARK 12 re-entry vehicle, MINUTEMAN II. DESCRIPTION: 2nd-generation ICBM; weight, over 65,000 lbs.; solid propulsion; warhead, nuclear; 3 stages; range, over 5,000 mi.; guidance, all-inertial, target selected in seconds; 32-sec. reaction time. STATUS: MINUTEMAN II flight-test program (36 shots planned) began Sept. 24, over 700 MINUTEMAN I now operational; 1,000 missiles through FY '65; advanced version can be fired by airborne command posts; deployed in hardened and dispersed silos; MINUTEMAN II expected operational 1965, to be co-located with MMI; also some of the II's replace earlier models; MMII has greater accuracy and range/payload than I version. First overland shot, Mar. 1.

NIKE-HERCULES (MIM-14B) (Army)

Western Electric, prime; Western Electric, guidance; Hercules and Thiokol, propulsion; Douglas, airframe. DESCRIPTION: Surface-to-air, antiaircraft, tactical; weight, 10,000 lbs.; solid propulsion; warhead, nuclear or H.E.; range, 75 mi.; guidance, command; Mach 3+; ceiling in excess of 150,000 ft. STATUS: Over 80 batteries deployed in U.S. being turned over to National Guard; over 10 N-H batteries deployed overseas; Japan plans additional procurement; being equipped with HIPAR, a high power acquisition radar, and antitactical-ballistic-missile capabilities. Re-location of some Hercules batteries under consideration by JCS.

NIKE-X/Zeus (XLIM-49) (Army)

Western Electric, prime; Bell Telephone, guidance; Thiokol/Lockheed, propulsion; Douglas, airframe. DESCRIPTION: Antimissile missile, 3-stage; weight, 22,800 lbs.; solid propulsion; warhead, nuclear; range, 200-mi.; guidance, command; length, 48 ft.; diameter, 36 in.; fin span, 10 ft. STATUS: Missile is now part of NIKE-X missile "mix"; development, except as part of X, has ended; no intercept "failure" in more than a year of tests; $10 million requested for preliminary production engineering in FY 1966.

NIKE-X (Army)

Western Electric, prime; Bell Telephone, guidance; Thiokol, ZEUS propulsion; Douglas, ZEUS airframe; Martin Marietta, SPRINT missile prime; Hercules and Lockheed, SPRINT propulsion. DESCRIPTION: Successor to ZEUS as an anti-ICBM system; uses a mix of ZEUS/SPRING missiles and multi-function array radar (MAR). STATUS: Engineering development; funded at $334 million in FY '65 on accelerated development schedule, but deployment still deferred, GE will submit proposals on a hardened Nike-X system. Tests to be conducted late this year with MAR at WSMR, New Mexico, could provide basis for deployment decision; deployment cost: $12-20 billion.

PERSHING (MGM-31) (Army)

Martin, prime; Bendix, guidance; Sperry Farragut, fuzing and aiming; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; two-stage solid propulsion; warhead, nuclear; range, approx. 400 n.mi.; guidance, inertial; transported on FMC M474 tracked vehicles; replaced REDSTONE. STATUS: Flight test program completed; troop firings from Ft. Wingate, N.M., to White Sands being conducted; number of missile-loaded launchers per unit to be increased; West Germany organizing two battalions; first U.S. PERSHING battalion deployed to Germany in April, 1964.

PHOENIX (AIM-54) (Navy)

Hughes Aircraft Co., prime; Rocketdyne, propulsion. DESCRIPTION: Air-to-air missile for use with the F-111B fighter aircraft; each aircraft will be able to carry six missiles. Missile control system designated AN/AWG-9; and missile/bomb launcher is MAU-48A. STATUS: Development. First flight test planned in March, 1966. $71 million in FY '66 funds; Phoenix development problems delaying F-111B production.

POLARIS (UGM-27 A, B, C) (Navy)

Lockheed, prime; GE/MIT/Hughes/Honeywell/Raytheon, guidance and fire control; Aerojet-General/Hercules, propulsion; Lockheed, re-entry vehicle; Nortronics, checkout; Autonetics/Sperry, SINS; Westinghouse, launching equipment; Vitro, systems engineering coordination and training; Systron-Donner, ignition programming. DESCRIPTION: Underwater- and surface-to-surface; weight, 30,000 lbs.; solid propulsion; warhead, nuclear; range, 1,200 n.mi. (A-1), 1,500 n.mi. (A-2), 2,500 n.mi. (A-3); guidance, all-inertial. STATUS: 19 subs operational each with 16 missiles; A-1 aboard first five submarines; A-2 aboard subs 6-18; A-3, operational in August, 1964, aboard subs 19-41; total of 41 POLARIS subs authorized; deployed in Atlantic and Mediterranean; Pacific deployment began in 1964; British to buy A-3 missiles from U.S. B-3 (now called POSEIDON) ready for program definition with FY '65 funds; designed for twice the accuracy of POLARIS A-3. Lockheed remains POSEIDON prime, has contract for PDP.

QUAIL (ADM-20C) (Air Force)

McDonnell, prime; McDonnell Electronics, guidance; GE, propulsion; Thompson Ramo Wooldridge, ECM equipment. DESCRIPTION: ECM-carrying decoy, which simulates B-52 bomber, to enemy radar; turbojet powered; range, 250 mi.; guidance, gyroscopic autopilot. STATUS: Deployed at SAC bases; carried by B-52; procurement completed FY '61; advanced version with 400-mi. range has been flight tested.

REDEYE (MIM-43) (Army)

GD/Pomona, prime; Atlantic Research, propulsion. DESCRIPTION: Surface-to-air; weight, 28 lbs.; solid propulsion; warhead conventional; guidance, IR-homing; length, 48 in.; diameter, 2.75 in. STATUS: Production; tests against helicopters and jets at NOTS successful. Procurement begins with reprogrammed FY '65 funds and $67-million FY 1966 request.

REGULUS I (RGM-6) (Navy)

LTV Aerospace Corp., prime; Sperry, guidance; Allison, propulsion. DESCRIPTION: Surface-to-surface; weight, 14,000 lbs.; turbojet and solid propulsion; warhead, nuclear; range, 500 n.mi.; guidance inertial; speed, about 600 mph; ceiling, approx. 40,000 ft. STATUS: Five REGULUS subs with 17 missiles are operational now; 3 subs (8 missiles) will be phased out in FY '65.

SAM-D (Formerly AADS-70) (Army)

Hughes/Douglas/FMC, RCA/Beech, competitive component development contracts. DESCRIPTION: Field army ballistic missile defense system, mobile. STATUS: No decision to develop system has been made; component development funded at $5 million in FY '65; additional FY '66 funding expected to provide basis for system definition studies in FY '66.

SERGEANT (MGM-29A) (Army)

Sperry Utah, prime; Sperry, guidance; Thiokol, propulsion. DESCRIPTION: Surface-to-surface; weight, 10,000 lbs.; solid propulsion; warhead, nuclear; range, over 75 n.mi.; guidance, inertial; uses drag brakes. STATUS: Operational procurement complete; deployed in Europe; replacement for CORPORAL; West Germany buying system. $1.9 million requested in FY 1966 for warhead adaption kits.

SHILLELAGH (MGM-51A) (Army)

Philco Aeronutronic, prime Picatinny Arsenal/Amoco Chemicals Corp., propulsion; Aeronutronic, guidance. DESCRIPTION: Surface-to-surface; lightweight; solid propulsion; warhead, nuclear or H.E.; guidance, command; vehicle-mounted for use against field fortifications, armor and for close-in support of troops. STATUS: Production. Initial procurement in FY '65; to use multi-system test equipment; engineering development stage began in FY '64; to be installed on Gen. Sheridan assault vehicle; also being considered for use on helicopters.

SHRIKE (AGM-45A) (Navy)

Naval Ordnance Test Station-China Lake, prime; Texas Instruments, guidance and control; North American Rocketdyne (McGregor), propulsion. DESCRIPTION: Air-to-surface, anti-radar; solid propulsion; guidance, passive radar homing. STATUS: Operational; armament for Navy and Air Force tactical aircraft.

SIDEWINDER 1-C (AIM-9D) (Navy, Air Force)

Naval Ordnance Test Station, technical direction; Philco, guidance; Naval Ammunition Depot, McAllister, motor loading; Rocketdyne (McGregor), propellant. DESCRIPTION: Air-to-air; weight, about 155 lbs.; solid propulsion; warhead, H.E.; range, more than 2 mi.; guidance, IR. STATUS: 1-A deployed with Navy and Air Force; 1-C version being procured as replacement for 1-A; NATO-built version now in production. (See CHAPARRAL).

SPARROW III-6B (AIM-7E) (Navy)

Raytheon, prime; Raytheon, airframe, control, guidance; Aerojet-General/North American Rocketdyne (McGregor), propulsion; McDonnell/Benrus Watch Co., launcher. DESCRIPTION: Air-to-air; weight, 350 lbs.; solid propulsion; warhead, conventional; range, 5-8 mi.; guidance, semi-active CW homing; Mach 2.5-3; ceiling, over 50,000 ft. STATUS: Earlier models operational with carrier aircraft; SPARROW III-6B prime armament for Phantom II (F-4B) and other high-performance interceptors. SEA SPARROW, a shipboard-launched adaption being considered by Navy as a point-defense weapon for small vessels; would use 3-in. modified gun mount as launcher. British F-4 buy expected to include SPARROW missiles; U.S. procurement terminates with FY '66 buy.

SPRINT (Army)

Martin-Orlando, prime; Hercules Powder/Lockheed Propulsion Co., propulsion; Bell Telephone Laboratories, guidance. DESCRIPTION: High-acceleration cone-shaped missile for low-altitude interception of ballistic missiles; 4.5-ft. base diameter, 27 ft. long; two-stage; nuclear; missile will be popped out of silo before motor is ignited; to be part of the missile mix in a NIKE-X battery. STATUS: Development; first flight in March '65 tested vehicle aerodynamically but without gas-generator pop-up procedure; SQUIRT vehicle to be used to test materials and components for SPRINT at White Sands Missile Range; pop-up tests to prove silo ejection concept and mechanism under way at Martin-Orlando plant.

SRAM (Air Force)

No contractors selected. DESCRIPTION: Air-to-surface defense-suppression standoff missile for use with the B-52, B-58 F-III or the Advanced Manned Strategic Aircraft. STATUS: PDP proposals due Apr. 30 '65, to be evaluated by AF; full-scale development to begin early in 1966; AF contracting feasibility tests for LASRM (Low-altitude Supersonic Research Missile), aiming at doubling SRAM's range.

STANDARDIZED MISSILE (Navy)

No contractors. DESCRIPTION: Fleet air-defense missile to replace TARTAR-TERRIER and give Navy a single missile to perform both missions; longer-range targets would be engaged by adding a booster to the shorter-range weapon; similar to the homing TERRIER now being procured. STATUS: Development; expected to be procured initially in 1967-68.

SUBROC (UUM-44A) (Navy)

Naval Ordnance Laboratory, technical direction; Goodyear, prime; General Precision Aerospace, guidance; Thiokol, propulsion; General Precision Librascope, fire control. DESCRIPTION: Underwater-air-underwater antisubmarine missile depth bomb; solid propulsion; warhead, nuclear; weight, 4,000 lbs.; length, 21 ft.; diameter, 21 in.; range, 25-30 mi.; guidance, inertial. STATUS: Production scheduled for installation in Thresher-class subs; operational evaluation under way; $23 million requested for FY '66 procurement.

SS-10 (Army)

Nord Aviation, prime. DESCRIPTION: Surface-to-surface, primarily antitank; weight, 33 lbs.; solid propulsion; warhead, conventional; range, 1,600 yards; wire-guided. STATUS: Operational with U.S., French and other NATO and Western units; battle-tested in North Africa; U.S. replacing with ENTAC.

SS-11 (Army)

Nord Aviation, prime. DESCRIPTION: Surface-to-surface antitank, also helicopter-to-surface; weight, 63 lbs.; solid propulsion; wire-guided; warhead, conventional; range, 3,800 yds. STATUS: Operational, to be used with airborne units and Army helicopters.

TACTICAL PROBE (Navy)

Bendix, prime: DESCRIPTION: Surface-to-air; multiple, interchangeable payloads for each mission; booster, TERRIER or TALOS from shipboard installations; high-impulse second stage; range, 50-300 mi.; parachute descent. STATUS: Program definition; a new study has been authorized, and is under way, to evolve a cheaper program.

TALOS (RIM-8E) (Navy)

Bendix, prime; Vitro, systems engineering; McDonnell/Hercules Allegany Ballistics Lab., propulsion; Sperry, guidance; GE, launching gear. DESCRIPTION: Ship-to-air; weight, 7,000 lbs.; solid and ramjet propulsion; warhead, nuclear; range, 65 n.mi.; guidance, radar beam riding/semi-active homing; Mach 2.5. STATUS: Operational aboard cruisers Galveston, Little Rock & Oklahoma City and three Albany-class DEG's; Long Beach, nuclear-powered cruiser, has advanced TALOS; "3-T" get-well program increasing reliability; procurement continues in FY '66.

TARTAR (RIM-24B) (Navy)

Vitro, systems coordination engineering; Applied Physics Lab, design and development; GD/Pomona, Aerojet-General, propulsion; Sperry Farragut, fuze (target detection device). DESCRIPTION: Ship-to-air; weight, 1,500 lbs.; solid dual-thrust motor; warhead, conventional; range, 10 n.mi.; guidance, semi-active homing; Mach 2. STATUS: Operational; installed aboard 23 guided missile destroyers and three cruisers equipped with TALOS; get-well program progressing satisfactorily; CVA Kennedy will also have TARTAR.

TERRIER (RIM-2E) (Navy)

Vitro, systems engineering; GD/Pomona, prime; GD/Pomona, guidance section; Sperry, radar; Hercules Allegany Ballistics Laboratory, propulsion; Northern Ordnance, launching gear. DESCRIPTION: Ship-to-air; weight, 3,000 lbs.; 27 ft. long; solid propulsion; warhead, conventional; range 10 n.mi.; guidance, radar beam-riding or homing; Mach 2.5. STATUS: Operational aboard two attack carriers, 6 cruisers, and 12 missile frigates; get-well program progressing satisfactorily.

TITAN I (HGM-24A) (Air Force)

TRW Space Technology Laboratories, systems engineering and technical direction; Martin, prime; Bell/Sperry, guidance; Aerojet-General, propulsion; Avco, re-entry vehicle. DESCRIPTION: ICBM; weight, 220,000 lbs.; LOX/RP-1 fueled; warhead, nuclear; range, 5,000 mi.; guidance, radio inertial; 90 ft. long; 2 stages. STATUS: Operational; 54 missiles at 5 bases. All will be deactivated by July, 1965.

TITAN II (LGM-25C) (Air Force)

Martin, prime; TRW Space Technology Laboratories, system engineering and technical direction; AC Spark Plug, guidance; Aerojet-General, propulsion; GE, re-entry vehicle. DESCRIPTION: ICBM; weight, 330,000 lbs.; N_2O_4 and Aerozine-50 storable fuels; warhead, nuclear; range, over 5,000 mi.; guidance, inertial; 115 ft. long; 2 stages; greatest payload and range of any U.S. ICBM, basic core vehicle for TITAN III booster. STATUS: All 54 missiles operational; one squadron (18 missiles) operational at Davis-Monthan AFB; one (18 missiles) at McConnell AFB and one (18 missiles) at Little Rock AFB.

TMRBM (Air Force)

No contractors announced, but probably would be same team producing the second and third stages of MINUTEMAN II. DESCRIPTION: A transportable mid-range missile to fill the gap left by cancellation of MMRBM; it would use the top two stages of MM II and the MM II guidance system; would weigh more and be less mobile than MMRBM, but could be developed for approximately one-third the cost; reaction time also less than MMRBM's; employment concept much the same as that of the Russian-deployed missiles in Cuba in 1962. STATUS: Study by the Air Force at DDR&E direction; not likely to be developed due to a lack of mission.

TOW (Army)

Hughes, prime. DESCRIPTION: Antitank; weight, 160 lbs.; solid propulsion; warhead, H.E.; wire-guided; optically tracked; tube-launched. STATUS: Development; follow-on to ENTAC; firings being conducted at Army Missile Command.

WALLEYE (Navy)

Naval Ordnance Test Station-China Lake. Navy has negotiated PDP contracts with Martin, NAA & Hughes. DESCRIPTION: Guided air-to-surface bomb; weight, 1,000 lbs., equipped with movable fins; propulsion type, none; warhead, high-explosive; range, several miles; guidance, TV contrast homing guided by pilot. STATUS: Engineering development; two production contracts will be awarded as well as one for additional development. Scheduled for FY 1966 deliveries to begin replacing BULLPUP B.

ZUNI (Navy)

Naval Ordnance Test Station, prime; Hunter-Douglas, propulsion. DESCRIPTION: air-to-surface; weight, 107 lbs.; solid propulsion; warhead, conventional; range, 5 n.mi.; unguided; STATUS: Operational; designed for use on jet fighter and attack aircraft.

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NASA'S NEW

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A SPECIAL REPORT...

...to be published in MISSILES AND ROCKETS May 31, 1965 issue. The new center, although just entering the construction phase, has already issued RFP's to industry for electronics research contracts. The center which will eventually direct 50% of NASA's electronics research, has a FY '66 budget which already has reached $22 million, and by 1969 should reach $100 million.

More important, the Electronics Research Center will be in the forefront of NASA's drive to achieve the state-of-the-art advances in electronic systems and components required to carry out the sophisticated space missions planned in the late sixties and through the next two decades.

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Rock Samples Match Lunar Properties

Bendix Systems Div. upwells and expands magma in high-order vacuums to form samples photometrically agreeing with lunar curve

by John F. Judge

SYNTHETIC ROCK samples which match the photometric properties of the Moon's surface without exposure to radiation are under study at the Bendix Systems Div., Ann Arbor, Mich.

The rock samples are created by upwelling or expanding magma in high-order vacuums. Both basalt and granite samples have been used. The process, developed by Walter I. Dobar, Manager of the Quality Assurance Dept., consists of melting geological samples and then quickly exposing the molten mass to vacuums in the 10^{-8} torr range (M/R, March 23, 1964, p. 36).

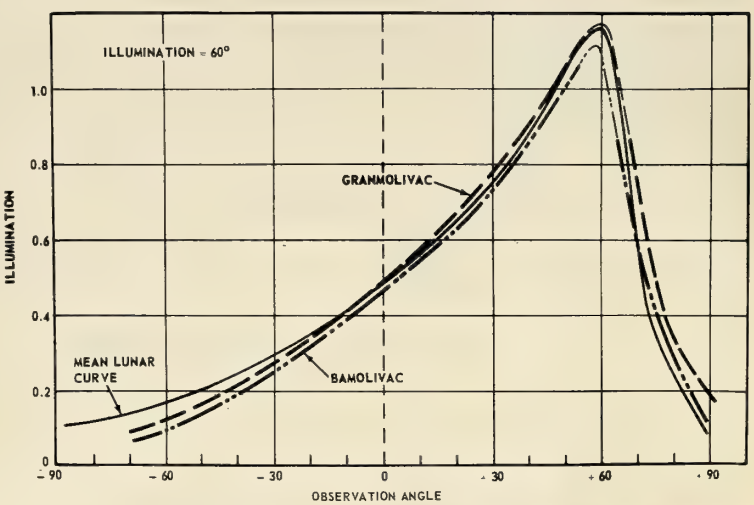
Dobar calls the expanded samples Bamolivac and Granmolivac (GRANite MOLten In VACuum) to maintain correlation with Earth-type rocks. The expanded material has no Earthly counterpart.

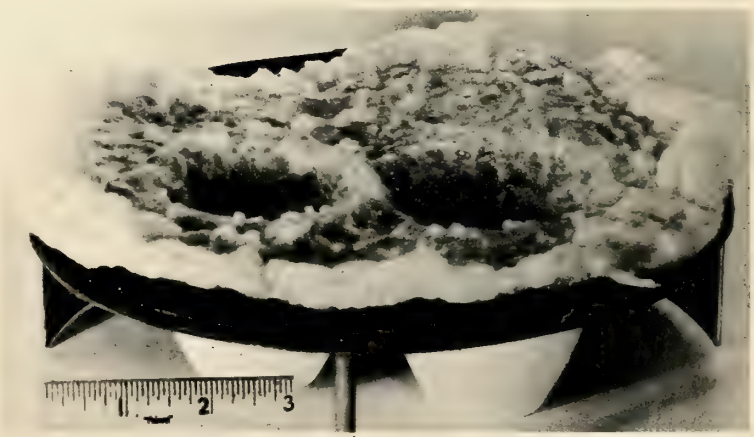
The photometric characteristics of both samples agree extremely well with the mean lunar curve (see chart). The mean densities of the upwelled samples are 1.76 grams/cm^3 for Bamolivac and 0.97 grams/cm^3 for Granmolivac.

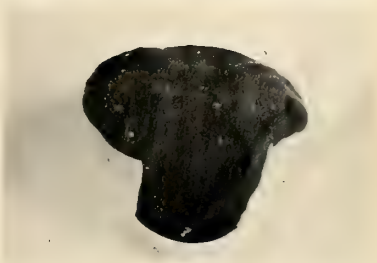
Dobar's previous work involved several types of silica (simolivac) in an effort to simulate with terrestrial materials the result of magma expanding through the lunar surface into the lunar vacuum. Exhaustive testing of such samples, both irradiated and non-irradiated, began to show correlation with various lunar measurements—thermal, albedo, light scattering, light polarization and colormetric analysis.

Several of the scientists responsible for determining the lunar surface have recently been referencing Dobar's work. Bendix is not trying to define the lunar surface as such—the main point is that if certain portions of the surface can be simulated accurately with terrestrial materials, substantial progress can be made with a minimum of "hard" data from lunar missions.

The bearing strength in unconfined compression of the Wausau Simolivac developed in earlier experiments is approximately 4 tons/sq. ft. Bearing strengths of the basalt and granite samples are still being determined. ■







TOP: Chart shows photometric curves for Bamolivac and Granmolivac—mean lunar surface. ABOVE: Large samples of Simolivac upwelled into the vacuum at 1,000°C. This sample formed a peculiar crater structure. RIGHT: Cross-section of sample of Bamolivac obtained by upwelling into vacuum at 700°C. In other tests, Bamolivac was expanded at 1,000°C into a high-order vacuum, as were samples of Granmolivac.

Facility Refines Motor Testing

Characteristics of conventional lathe adopted to simulate conditions solids will encounter spinning at high altitudes

THRUST ALIGNMENT of solid-propellant rocket motors can now be tested in high-altitude test cells at the Air Force's Arnold Engineering Development Center while the motors are spinning.

A spinning test rig operated since early this year at AEDC's Tullahoma, Tenn., facilities, makes it possible to detect and correct misalignment before it becomes a serious problem in actual space flight tests of spin-stabilized motors.

As requirements developed for increasingly accurate thrust and in-flight performance, ARO Inc. engineers needed a more precise method of checking thrust and alignment in vehicles or motors spinning under simulated high-altitude conditions. Developed under the direction of Paul M. Hood, an ARO engineer, and borrowing from the characteristics of a conventional machinist's lathe, the new device has proved highly successful.

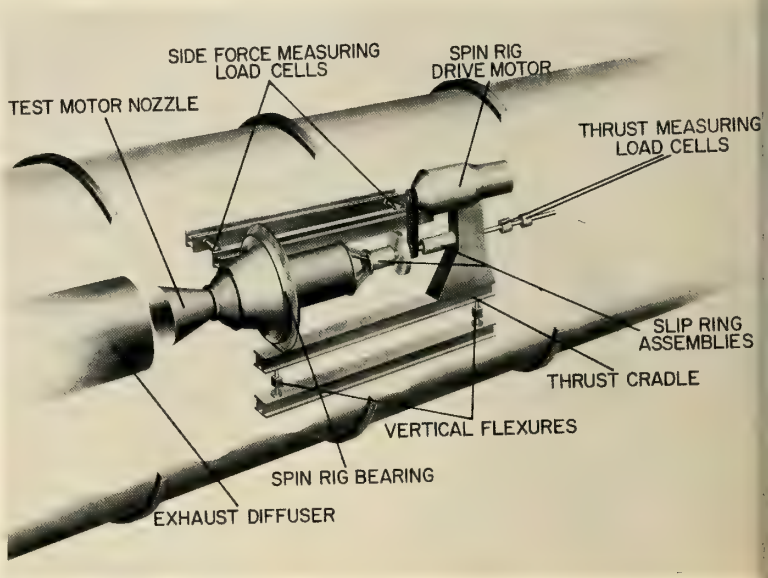
To provide accurate measurements, Hood and his associates mounted test rocket motors on a shaft turning in a spin rig closely resembling a lathe mandrel. With the shaft aligned with the longitudinal axis of AEDC's T-3 high-altitude test cell, the entire assembly is spun by a drive motor mounted on the mandrel.

Before the test rocket is fired, fine centrifugal adjustments are completed to be sure the entire assembly is spinning in perfect balance in the non-firing mode. Two sets of slip-ring assemblies provide a total of 104 electrical contacts to convey signals and to return data from the spinning test motor—controlling ignition, thrust and safety devices and transmitting readings on case strain, motor and case temperatures, heat flux to the motor, motor acceleration and vibration.

Once the test motor has entered its firing sequence, special side force-measuring load cells come into play, mounted on a beam closely resembling the steady rest on a machinist's lathe.

The beam, located parallel to the mandrel axis, has supersensitive strain gauges mounted at either end, electronically displaying thrust and rocket case alignment data derived from the spinning test motor assembly. Computer techniques permit engineers to "subtract out" data on eccentricities and vibrations in the motor case as they develop during the firing period, allowing them to concentrate on data specifically related to thrust alignment.

Once adequate spinning techniques were developed, technicians found that thrust misalignment indications were readily observed with a characteristic pattern identifying itself with each revolution of the spinning test motor assembly or cradle. A continuous picture of alignment conditions in the motor assembly could be compiled for the entire firing period.



SCHEMATIC shows major components of new spin test rig developed to detect and measure thrust misalignment in solid motors. Portion of shaft (right) that carries thrust-measuring load cells doesn't turn. Slip ring assemblies in center are fixed in relation to motor assembly, turn with it on sleeve rotating about center shaft.

● **2,000-lb. goal**—Full-scale solid-propellant motors weighing up to 1,000 lbs. have been tested to date, developing thrusts on the order of 10,000 lbs. ARO's T-3 cell will ultimately accommodate motors weighing up to 2,000 lbs. with thrusts up to 20,000 lbs., AEDC spokesmen said. Early tests were completed with the test motor assembly spinning at 60 to 200 rpm, and 900 rpm is the maximum spin rate achieved in tests to date. The mandrel equipment is capable of spinning motor assemblies at an optimum rate of 1,200 rpm.

Two sets of strain gauge thrust-measuring cells are mounted on the fixed mandrel shaft, upstream from the direction of motor thrust, to provide precise quantitative thrust measurements throughout each firing.

ARO's spin rig has already provided data that will prevent costly in-flight failures of sophisticated spin-stabilized

systems. One such motor, spin-stabilized at 200 rpm, had seven holes burned through it after testing at this spin rate under high-altitude conditions in the T-3 cell—even though the motor had performed satisfactorily on a fixed stand under similar conditions.

• **ATS rocket up for test**—Recent tests using the new sideload-measuring technique have been made on motors for Ling-Temco-Vought's *Scout* launch vehicle. Similar tests are scheduled in the near future on the apogee rocket designed to accelerate the Hughes-developed *Applications Technology Satellite (ATS)* vehicle into synchronous orbit around the Earth. As a second-generation technological vehicle, *ATS* will be used to investigate the usefulness of stationary Earth-synchronous satellites for communications and other purposes.

If the thrust of the apogee rocket motor were misaligned to a degree sufficient to overcome the *ATS* vehicle's built-in guidance and control, the satellite would develop wide oscillations and fail to achieve the design orbit. Precise data on thrust alignment is also of major importance in spin-stabilized systems operating in space *without* guidance control aboard. Elimination of thrust misalignment for such vehicles is of obvious importance in assuring satisfactory flight performance.

Checking of the thrust alignment for the *Surveyor* retro-motor is now under consideration but not yet scheduled at AEDC. Here, misalignment serious enough to exceed on-board guidance and control correction capacity could cause the vehicle to tumble in its approach to the Moon. Instead of braking the vehicle in its descent, the retrorocket might drive the vehicle into the Moon's surface.

• **Technology gains**—Successes achieved in tests with the new spin rig have contributed significantly to the techniques for detecting and measuring thrust misalignment. Earlier tests with stationary thrust stands inside high-altitude cells were hampered by vibration readings superimposed on data records, confusing the results. Other factors, such as changes in motor weight and center of gravity as the propellant burned, also contributed to the problem of separating out specific thrust alignment data on stationary rigs.

First spin equipment at ARO's Tullahoma facilities was brought in by NASA from its Langley Research Center. The NASA rig had been used in testing spin-stabilized motors under sea-level conditions. ARO engineers adapted the concept for use in the T-3 high-altitude cell and introduced additional devices permitting precise measurement of side loads. ■

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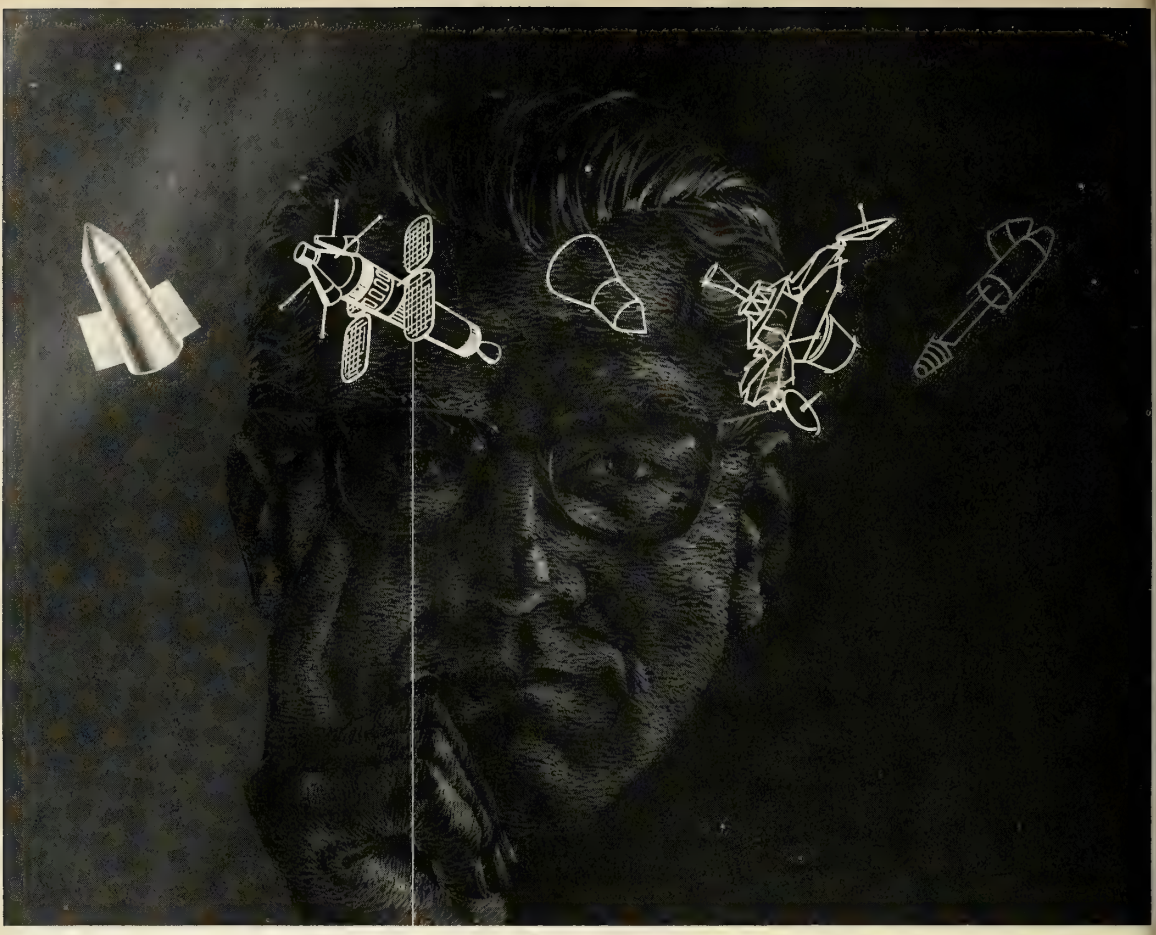

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Raytheon Continues Acquisition Program

by Michael Getler

LEXINGTON, MASS.—Raytheon Co., which last year set out upon one of the most vigorous programs of diversification-through-acquisition in the aerospace industry, is about to acquire still another firm.

With approval of the transaction, which Raytheon President Thomas L. Phillips told MISSILES AND ROCKETS "is virtually agreed to," the still-to-be-named firm will become the sixth major acquisition by Raytheon in 12 months. An official anouncement is expected late this month. Phillips also reports that "several other acquisitions are under active consideration."

The acquisitions, Phillips relates, are a key part of Raytheon's long range plans to "grow a company with several hundred million dollars in commercial business, but in no way entrenching our effort to grow in the defense segment."

Raytheon's 1964 net sales amounted to just over $454 million, including about $130-140 million in the commercial sector, with the remainder in the government area. However, Phillips notes that it is difficult to break down the figures categorically. He points out, for example, that some of the government business was non-defense, such as FAA work, and some of the $35-50 million in business done by the firm's Microwave and Power Tube Div., while listed as commercial, actually had a military end-product use.

The heavy acquisition activity, begun by the firm in 1964, has added about $40 million more thus far in commercial-type business, Phillips reports.

● **The acquisitions**—Last May, Raytheon bought up Penta Laboratories, Inc., a large Santa Barbara, Calif.-based manufacturer of high-powered pentode transmitting tubes with annual sales in excess of $1 million. In June, the firm acquired Micro State Electronics Corp., of Murray Hill, N.J., a producer of microwave components and semiconductor devices with annual sales of

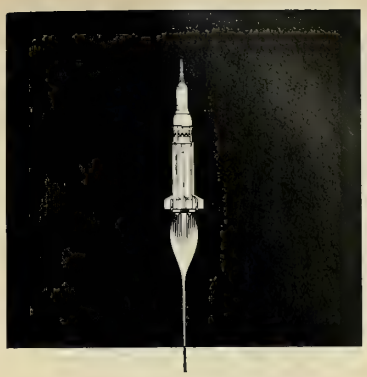
Overland Radar Solution Offered

RAYTHEON ENGINEERS have submitted a proposal to the Air Force for solution of the long-standing problem of radar detection of low-level aircraft over land.

Engineers here say that experience gained during work supported by the Advanced Research Projects Agency aimed at sorting of decoys from missile warheads has led to the choice of "a waveform which shows tremendous promise in detecting these low flying targets." The technique reportedly takes advantage of velocity- and wake-filtering techniques developed under the ARPA program. Raytheon says it has built various critical components of the system in a company-funded development effort.

The overland radar problem presents trouble from two sources—the need to compensate the radar platform's motion to simulate a fixed sensor platform, and the ability to pick out small, fast moving targets from a radar background of intense ground clutter. The inability to do this is a major bottleneck in the Air Force's Airborne Warning and Control System (AWACS) and a host of other service programs wherein a radar capability of this type could revolutionize air defense and direct air support missions (see M/R Special Report March 29, p. 109).

DOD and service project officers just recently reported that the technology to accomplish this task has not come forward. However, industry engineers do not completely share that view. Hughes and General Electric are also conducting major efforts in this area.



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The Applied Physics Laboratory's location in suburban Washington, D.C., gives you a choice of city, suburban, or country living. The area offers many benefits including excellent residential areas, complete service and recreational facilities, and good public and private schools. Programs leading to advanced degrees from The Johns Hopkins University are offered at the Applied Physics Laboratory. In addition, staff members may continue their education at six other universities in the area with APL financial support.

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about $2 million. In August, Raytheon announced the purchase of Packard Electronic Corp.'s Computer Div. in Santa Ana, Calif., an operation with an annual sales volume of $6-7 million. The computer memory portion of Philco's Aeronutronic Div., representing an annual business of $1-2 million, was acquired in January of this year.

Raytheon's largest, and in many ways most significant addition, came in March of this year with acquisition of the Amana Refrigeration Co. of Iowa, a firm that has showed a consistent record of profit and whose sales is tabbed at about $25 million.

Viewing the firm's acquisition program to date, Phillips feels Raytheon is an example of a firm that has chosen this path to diversification and come out all right. "Every profit earning firm which we acquired is operating more profitably now than when it was acquired," Phillips told M/R. Some of the smaller firms—one in particular, which Phillips did not single out—are seen as having good growth potential, but needing investment before turning the profit corner. Phillips feels that "all of the new acquisitions will be in the black in 1966."

The stepped up pace of Raytheon's acquisition program in recent months came too late to have much impact on the firm's 1964 performance. In 1964, Raytheon showed a 30% improvement in profit in the face of almost an 11% drop in sales, much of it traceable to cut-backs in missile production. The reason for the improved profit margins on lower sales, according to Phillips, was due primarily to the two major consolidations within the firm's industrial components and microwave and power tube operations.

● **Impact expected this year**—Phillips does expect the acquisitions to make their first important mark on Raytheon performance in 1965, not so much in terms of increased corporate earnings or volume, which he feels will be about the same as last year, but mostly in the important mix of business between commercial and military.

The mix is extremely important to a firm such as Raytheon, which has long been steeped in military business. While the return on sales in the commercial sector is better than in the military, Phillips observes, he also points out that return on investment and liquidity of assets in the defense sector is certainly competitive and possibly more favorable in some circumstances than it is in the commercial business. (Return on investment is mostly a factor of when a firm got into the defense business. The long-standing primes got healthy doses of government-furnished equipment during the past decade.)

Another important consideration of the business mix is an attempt to improve the firm's price/earnings ratio. These P/E figures are traditionally depressed in the defense stocks and can limit a firm's freedom of movement.

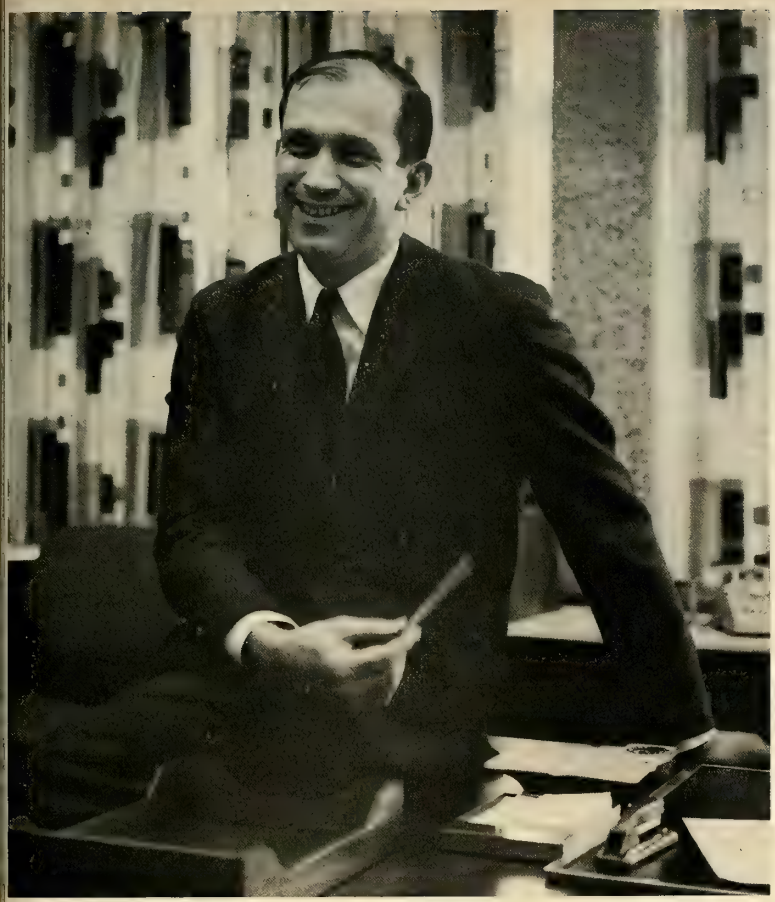
● **The criteria**—The areas in which Raytheon has set its commercial growth sights are communications, data processing, educational systems, components, and consumer products. The firm, Phillips reports, will seek to acquire companies that in Raytheon's view have either the at-hand capability, or the potential, to grow at rates faster than the Gross National Product. The firm views potential acquisitions in terms of matching the needs of the company for increased volume in the commercial sphere, using two basic ground rules: one is applied to firms outside the current sphere of corporate activity, such as Amana, where acquisition of the firm's management is essential; and another involves acquisition of firms in fields where existing Raytheon capabilities either in sales or technology can build up a smaller outfit to a sum greater than the separate parts.

Raytheon views its program as an orderly one, and the Amana acquisition, in this light, is most important. It has moved the firm into the consumer area with a relatively large company, and the operations to date, according to Phillips, have encouraged Raytheon to proceed with its planned expansion.

A Raytheon report for the first quarter of 1965 issued last month included for the first time the first full quarter results of Amana, which Phillips said "is enjoying excellent business."

Phillips stresses that the object of Raytheon's program is "to diversify not convert" from the defense sector. "The company's strength is in technology and we still see a very large defense market and an opportunity for a better return on investment and more profitable operation under new fixed price contracting procedures." The intent to grow within the defense business is based on internal development of the firm rather than through acquisition. Referring to the cut-backs in 1964, Phillips says "we are sort of lean now, in a position to run our present volume efficiently, and we don't intend to get overextended."

● **Military backlog up 10%**—Raytheon's current military backlog actually increased in the first quarter of '65 to $235 million, up 10% over the same period last year. New military business potential rests in programs such as the *Nike-X* radar site array and transmitter programs, possible foreign national sales of the *Sparrow III* missile, and a strong possibility for a European consortium-type undertaking on a *Hawk* improvement program similar to the one now in progress in the U.S. The *Hawk* is also under evaluation by the Army as an anti-



Raytheon President Thomas L. Phillips: "Diversification, not conversion."

tactical missile weapon system (M/R, Feb. 15, p. 9), and the *Sparrow* is also at least a contender for an air-to-air armament role with the Air Force's F-111. *Sparrow* is also being eyed as a sea-based missile for point defense of the fleet (M/R, March 22, p. 14).

The firm, whose major strength through the years has rested heavily in the radar area, is also a contractor in the DOD's over-the-horizon-radar projects and has recently proposed a technique to the Air Force, that top company officials feel will be successful in finding solutions to the problem of overland radar target detection (see box).

In terms of its government-funded business, awards for space R&D and hardware still occupy a comparatively small portion of Raytheon's total volume. Phillips feels that in the past two years the company has done a great deal to improve its position however, primarily due to the efforts of his next door neighbor in the Raytheon corporate offices here, former NASA Manned Space Flight Director, D. Brainerd Holmes.

● **Sorting out missions**—"Raytheon's problem in space has been timing," Phillips asserts. "The important thing we did not do until 1963 was separate our space activities from our missile division." Early in '63, Raytheon finally split its Missile and Space Div. into the Space and Information Systems Div. and the Missile Systems Div. "We should have started what is now an aggressive effort in space five years ago, not two. By the time the Space Div. was functioning, many of the big NASA primes in the *Apollo* effort were already let."

Holmes, who left the directorship of NASA's manned space flight program in June '63, was named a Raytheon senior vice-president later that year. Phillips believes that the combination of the new divisional structure, plus the activities of Holmes in the technical and management development areas, will put the firm more squarely into the space sector during competitions for post-*Apollo* projects. In that era, Phillips believes the prime contractor status may be more conducive to electronic-based firms, much as the *Apollo* efforts have been placed largely in the hands of the major airframe companies. ■

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AGE systems include launch base equipment, computer controlled data processing systems, and digital hardline command systems.

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TECHNICIANS collapse Parafoil following flight.

space support

Parafoil Shows Potential For Spacecraft Recovery

by Rex Pay

CHINA LAKE, CALIF.—A tethered Parafoil has demonstrated its ability to carry aloft a cloud-seeding silver iodide flare here.

An untethered Parafoil has also demonstrated gliding flight with a small payload.

The Parafoil is a fabric airfoil that maintains its shape by ram air pressure. It is self-inflating.

Tests in a wind tunnel at the University of Notre Dame have shown that flow over a Parafoil is "extremely good and is not distinguishable from the streamline pattern over a similar rigid airfoil."

The university has dropped Parafoils from aircraft at altitudes of 500 and 1,000 ft. They flew in a stable manner in all cases.

Notre Dame tested Parafoils with an aspect ratio of 1 and per cent thickness ratios of 10% and 20%.

● **Characteristics**—Developed by Domina C. Jalbert of Space Recovery Research Center, the Parafoil is extremely light and has shown lift-to-drag ratios exceeding 3. Notre Dame predicts L-D ratios of 8 to 10 if aspect ratio is increased.

Jalbert reports that the wing can be flown in a controlled manner (circular or figure of eight patterns, for example) by application of small control forces.

He sees a potential use for free-flying Parafoils as recovery systems for space vehicles and boosters.

When tethered, the Parafoil can be flown like a kite, and in this form it will be used for Naval Ordnance Test Station rain-making experiments in the California Sierras.

Pan American World Airways, Inc., has bought tethered versions to lift antennas for down-range communications during *Gemini* recovery.

The Parafoil purchased by NOTS is rectangular, 9 ft. across by 12 ft. long. The upper surface has an airfoil curve and is joined to the lower surface by a series of vertical fabric walls that run fore and aft. These form 10 parallel constant-width compartments.

Air enters the open mouth of each of these compartments and flows through the wing, to exit through a small vent in the trailing edge. It is this air that keeps the Parafoil inflated.

Total weight of this wing is 7 lbs. It will lift 50-100 lbs. in a light breeze.

● **Flight behavior**—When launched from the ground on a tether, the Parafoil assumes the very high angle of attack that is typical of a kite. It acts virtually as a flat plate that rides up on the wind by reaction forces. As it pulls its tether wire upright, however, it begins to develop lift, and soars like a glider. It functions as an airfoil at angles of attack between 45° and 10°.

PARAFOIL in middle of tethered flight.

The tether line is typically 70-80° n normal soaring operation, and the ngle of attack is 10°. A tail drogue is dded for stability, but is not always ecessary. A five-knot wind is needed to ly the Parafoil, but it performs best in wind of 15-20 knots.

Head of the Earth and Planetary Sciences division at NOTS, Dr. Pierre St. Amand believes the Parafoil will be of considerable value in cloud-seeding experiments. Silver iodide flares have been dropped from A3D and AT6 aircraft previously. The Parafoil will give a safer means of getting silver iodide into the clouds.

It will enable a check on how cloud-seeding effectiveness varies with the temperature level at which the silver iodide is released. A series of temperature intervals between 0°C and −20°C will be seeded. This will probably involve flying the Parafoil at about 2,000 ft.

Jalbert reports that tests he has carried out show that the Parafoil will operate in winds up to 70 knots and also in rain and snow.

● **Size range**—The largest Parafoil that Jalbert has produced is a 300-sq.-ft. model weighing 19½ lbs. The smallest is a 4 oz. version designed as a life raft antenna.

Tests were made on the largest Parafoil at NOTS, using an amphibious "duck" that has been fitted with a winch and tensiometer for high-altitude tethered-balloon experiments. These experiments are aimed at flying tethered balloons at altitudes up to 100,000 ft.

The drum on the duck has about 55,000 ft. of glass-fiber tether line and is a useful kite-flying machine. The kite is attached and launched after sufficient line is paid out. It may either gain altitude in the surface wind or it can be pulled up by driving the duck across the desert. If neither course of action results in substantial altitude gain, the kite can be brought in on the winch. ■

WHO SAYS BUSINESS IS BAD?

MILITARY PUBLICATIONS

	1st 3 Mos. 1965	1st 3 Mos. 1964	Percent Change
ARMED FORCES MANAGEMENT*	**138**	**73**	**+89.0%**
Army	85	61	+39.3
Data	44	34	+29.4
Ordnance	59	53	+11.3
Journal	96	89	+ 7.9
Signal	71	66	+ 7.6
USNIP	76	73	+ 4.1
Air Force	98	111	−13.7
	667	560	+19.1%

AEROSPACE PUBLICATIONS

	1st 3 Mos. 1965	1st 3 Mos. 1964	Percent Change
MISSILES AND ROCKETS*	**272**	**283**	**— 3.9%**
Aviation Week & Space Technology	714	779	— 8.3
Space Aeronautics	220	333	−33.9
	1206	1395	−13.5%

AVIATION PUBLICATIONS

	1st 3 Mos. 1965	1st 3 Mos. 1964	Percent Change
AMERICAN AVIATION*	**125**	**102**	**+22.5%**
Flying	164	140	+17.1
B/CA	138	125	+10.4
AOPA	152	151	+ .7
Flight	114	118	— 3.4
	693	636	+ 9.0%

*American Aviation Publications UP 16.8%

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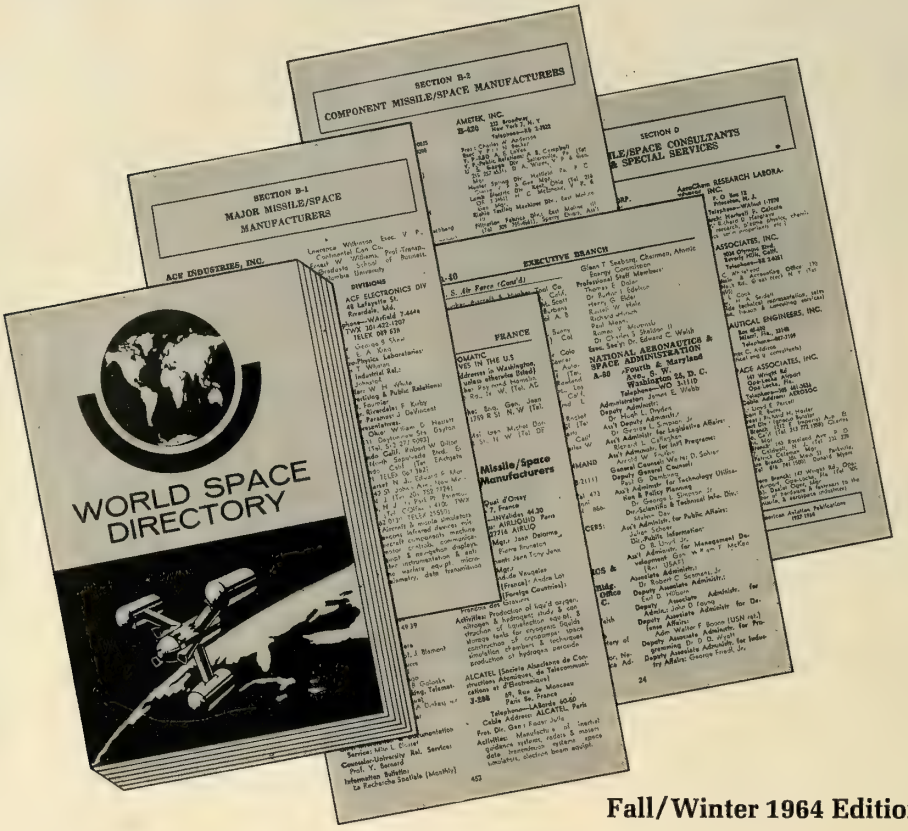

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Systems Effectiveness Topic of EIA Meeting

Members of the Electronic Industries Assn. will hear 28 authorities from Defense Dept., military, NASA and industry during a conference on "Systems Effectiveness: Why; Where; Whence Tomorrow" Oct. 19-20 in Washington. The conference will be sponsored by the EIA Engineering Department's Military Electronic Systems Committee. To be discussed will be the need for, status and future of systems effectiveness, with special emphasis on the technical, cost and marketing aspects of systems effectiveness.

Mergers and Acquisitions

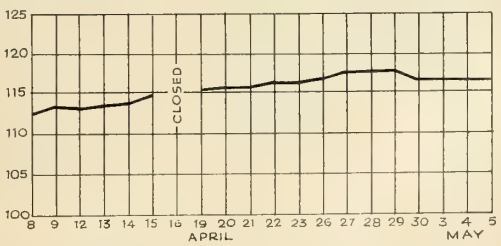
The boards of directors of Varian Associates and Eitel-McCullough, Inc., have approved the merger of Eitel-McCullough, a San Carlos, Calif., manufacturer of electronic power tubes and telemetry equipment into Varian. The agreement calls for a stock exchange of one share of Varian for two of Eitel-McCullough. Varian, a Palo Alto, Calif., developer and manufacturer of analytical instruments, high vacuum equipment and linear accelerators, views the move as a further diversification. Final approval requires approval of stockholders of both firms. . . . *Brown Engineering Co. of Huntsville, Ala., has acquired all outstanding capital stock of Electro-Mechanisms, Inc., Metheum, Mass., and Nashua, N.H. E-M will retain its corporate identity, but operate as a subsidiary of Brown. E-M makes flexible printed cable, layered circuitry and similar electronic products having application in the packaging of microcircuit elements into electronics systems.* . . . GCA Corp., Bedford, Mass., and Precision Scientific Co. of Chicago have agreed in principle to the acquisition by GCA of the business and assets of PSC. PSC makes a line of laboratory and process control equipment; GCA, precision measuring and other technical instruments, industrial processing systems and vacuum equipment, and performs research and development in aerospace and other fields. . . . *The United Shoe Machinery Corp., Boston, has purchased for an undisclosed amount of cash the business of Nylok Corp., Paramus, N.J. Nylok converts threaded fasteners to self-locking fasteners with inserts of nylon pellets or strips for use in the aerospace and automotive industries. Included in the transaction are all physical assets of Nylok and the assumption of certain liabilities related to Nylok's business.*

New Activities

Union Carbide Corp. has announced the establishment of an Aerospace Materials Dept. within its Carbon Products Div. Main products of the new department will be UC's line of graphite and carbon cloth and fibers for use in high-temperature applications. . . . *Electronic Communications, Inc., has established a new microelectronics laboratory in St. Petersburg, Fla. The laboratory facility, when completed late this spring or early in the summer, will concentrate on research in thin-film techniques and hybrid circuitry for digital and analog applications. A research project presently under way at EC is investigating a new technique for depositing thin-film circuits on microminiaturized substrates.* . . . Thompson Ramo Wooldridge, Inc., Cleveland, has changed its corporate name to TRW, Inc. Reason given is that the company was becoming better known by its initials than by the full formal name. . . . *Northrop Corp.'s Nortronics Div. has formed a new department to be known as the Applied Research Dept. Staff of the new operation initially will be composed of some 40 specialists in nuclear effects presently working in the Research and Advanced Technology Section of Northrop Ventura in Newbury Park, Calif. The new department will continue to be housed in the Newbury facility until arrangements are completed for a move to the nearby Rancho Conejo Industrial Park.* . . . Ehrenreich Photo-Optical Industries of California, Inc., has consolidated the West Coast Offices of its sales, technical and manufacturing branches in its Campbell, Calif., headquarters. Ehrenreich Photo-Optical is the military and special products division of the parent Ehrenreich organization. The move of the sales department from its former Palo Alto location is expected to facilitate EPOIC's program for handling purchase orders for Government and Industry. The East Coast sales office will remain at its present location in Garden City, N.Y. . . . *Fairchild Camera and Instrument Corp., Syosset, N.Y., has formed a new Instrumentation Div., which will be headquartered in Clifton, N.J. The division will combine the electronic equipment capabilities of both the Semiconductor and Du Mont Laboratories divisions and will market the products of the two divisions.*

Missile/Space Stock Index

Entry of U.S. forces into the conflict in the Dominican Republic caused another upswing of the Missile/Space Stock Index. Continued emphasis on defense activities and generally favorable financial reports by companies in the aerospace field have kept the figure at a record high level over the 115 mark, hitting a high for the year of 117.66 on Thursday, April 29.



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

AWARDS

AIR FORCE

$6,000,000—**The Boeing Co.,** Seattle, initial segment of $16-million contract for *Minuteman* modernization program.

$1,985,781—**Cardion Electronics, Inc.,** Westbury, N.Y., for radar sets and decoder units.

$1,806,570—**General Electric Co.,** Philadelphia, for design, development, test and manufacture of a test satellite.

$1,797,184—**North American Aviation, Inc.,** Anaheim, Calif., for spare parts for *Minuteman* missile guidance equipment.

$713,800—**Aerojet-General Corp.,** Nucleonics Div., San Ramon, Calif., for research in magnetic containment, neutral injection and plasma energy and momentum conversions.

$295,000—**Technical Measurement Corp.,** Telemetrics Inc., Santa Ana, Calif., for four additional Model 602 time division multiplex test stations.

$274,000—**Melpar, Inc.,** Falls Church, Va., to design and build an airborne antenna-pointing and Doppler prediction computer system.

$150,000—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for research on the selection, testing and evaluation of materials for application to uncooled solid and liquid rocket nozzles using high-performance propellants.

$150,000—**Radio Corp. of America,** RCA Laboratories, Princeton, N.J., for research on solid-state laser explorations.

$137,459—**American Science and Engineering, Inc.,** Cambridge, Mass., for design and fabrication of a prototype IR sky mapper.

$82,500—**Wentworth Institute,** Boston, for research and development of chemical release rocket payloads, observation systems and data collection.

$75,000—**Systems Research Laboratories, Inc.,** Dayton, Ohio, for research on energy exchange mechanisms and thin-film preparation and measurement techniques.

$74,600—**Booz-Allen Applied Research Inc.,** Bethesda, Md., for technical and engineering services to provide design criteria for an environmental laboratory.

ARMY

$4,694,250—**Hercules Powder Co.,** Radford, Va., for various explosives.

$3,234,269—**Sperry Rand Corp.,** Salt Lake City, Utah, for *Sergeant* missile modification kits.

$2,381,784—**Raytheon Co.,** Andover, Mass., for engineering services provided to the Army Missile Command.

$1,327,884—**Emerson Electric Co.,** St. Louis, for *Honest John* rocket parts.

$1,099,000—**Lockheed Aircraft Corp.,** Burbank, Calif., first segment of a $5-million contract for instrumentation work at the White Sands Missile Range, N.M.

$974,236—**Smith and Sapp,** Orlando, Fla., for construction of two maintenance buildings for cars and heavy equipment at the Merritt Island Launch Area.

$900,000—**General Electric Co.,** Direct Energy Conversion Operation, West Lynn, Mass., for continued development of hydrocarbon fuel cells.

$405,750—**American Science and Engineering, Inc.,** Cambridge, Mass., for design, fabrication, payload integration and proof-testing of experimental prototype *Nike-Hercules* test vehicle.

$357,000—**Lockheed Aircraft Corp.,** Lockheed Propulsion Co., Redlands, Calif., for research and development activity at White Sands Missile Range, N.M., for high-altitude research rockets and associated hardware.

$128,300—**General Dynamics Corp.,** Pomona, Calif., for *Redeye* guided missile items.

$79,993—**General Electric Co.,** Santa Barbara, Calif., for research and development study on strategic implications of hardsite defense for *Nike-X-A*.

NAVY

$26,272,073—**The Bendix Corp.,** Mishawaka, Ind., for *Talos* missiles.

$9,200,000—**Hughes Aircraft Co.,** Culver City, Calif., for continued work on the *Phoenix* air-to-air missile.

$6,759,658—**Sangamo Electric Co.,** Springfield, Ill., for sonar improvement kits.

$1,663,974—**Sanders Associates, Inc.,** Nashua, N.H., to make antennas for *Shrike* anti-radar missiles.

$1,469,340—**Baifield Industries Inc.,** Dallas, for supersonic target launchers.

$1,442,469—**Magnavox Co.,** Ft. Wayne, Ind., for production of sonobuoys for use in anti-submarine warfare.

$90,000—**The Boeing Co.,** Seattle, for follow-on studies of a proposed new advanced surface missile system.

ARMY AND NAVY

$3,500,000—**Ryan Aeronautical Co.,** San Diego, Calif., for production of *Firebee* jet target drones.

NASA

$335,000—**Garrett Corp.,** AiResearch Manufacturing Div., Los Angeles, for two flight-weight subcritical cryogenic oxygen storage systems.

$218,476—**Radiation Inc.,** Melbourne, Fla., for design, development and fabrication of an automatic tracking antenna system.

$117,699—**The Boeing Co.,** Seattle, for continued study of extruding refractory oxides, emphasizing the strengthening effects of extrusion and alloying.

$100,000—**Seegers Instrument Co.,** Barrington, Ill., for the manufacture of pressure transfer standards.

$94,800—**Defense Research Corp.,** Santa Barbara, Calif., for investigation of the generation of acoustical oscillations in liquid rocket combustion chambers.

$89,500—**Perkin-Elmer Corp.,** Norwalk, Conn., for an infrared optical system designed for use on future weather satellites.

$75,000—**The Bendix Corp.,** Filter Div., Detroit, for the investigation of oxidation resistant materials for transpiration-cooled gas turbine blades.

$35,860—**Electrada Corp.,** Airrite Div., Los Angeles, for *Apollo* service propulsion systems helium storage bottles for test and evaluation at the Manned Spacecraft Center.

Battelle Memorial Institute, Columbus, Ohio, to provide information to assist in planning future launch vehicles and propulsion systems for unmanned space exploration (amount not disclosed).

INDUSTRY

$4,650,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., from **Western Union,** New York City, for Autodin program.

$1,300,000—**Radio Corp. of America,** Electronic Components and Devices Div., Somerville, N.J., from **North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., for power circuits used in *Minuteman II* guidance and flight control systems.

$200,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., from **The Boeing Co.,** Seattle, increase for *Minuteman* spares.

$101,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., from **Collins Radio Co.,** Dallas, for *Apollo* VHF sets.

Carco Electronics, Menlo Park, Calif., from **North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., to produce the high-performance three-axis flight simulator for *Apollo* spacecraft (amount not disclosed).

EIMAC

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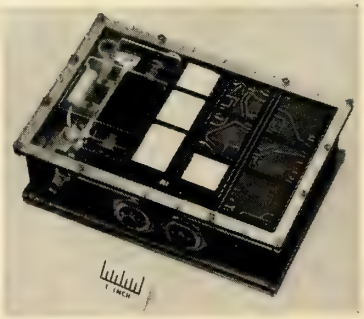
This 2-watt transmitter uses a triode-cavity power oscillator to achieve higher overall efficiency than is possible with all-solid-state transmitters. Frequency stability is achieved by an AFC servo loop referenced to a crystal oscillator. Tuning range is 2.2-2.3 Gc. Total volume is 48 cubic inches. Modulation linearity (maximum deviation from best straight line) is ±0.5% from ±10 Kc to ±300 Kc, and ±2.5% from ±10 Kc to ±1.5 Mc. Amplitude modulation is less than 1%. Susceptibility requirements of MIL-I-26600 are met. The solid state power supply operates from 28±4 Vdc with over 80% efficiency.



For information on the EM4527 transmitter, contact Eitel-McCullough, Inc., San Carlos, Calif. In Europe contact Eitel-McCullough, S. A., 15 rue du Jeu-de-l'Arc, Geneva, Switz.

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MODEL EM4567	8.0 WATTS	2.2 TO 2.3	Gc
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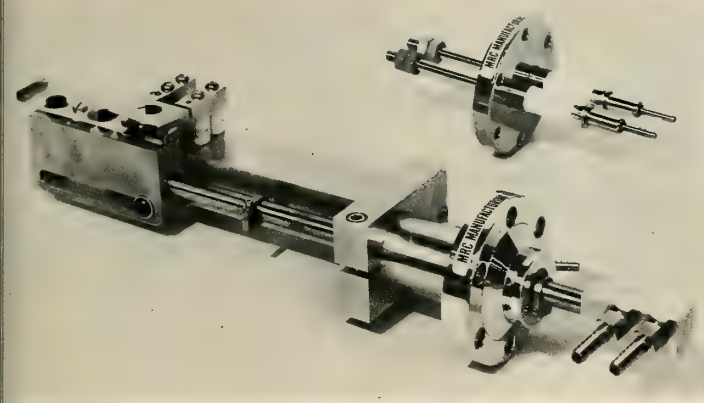


New Product of the Week:

Electron Beam Gun

An electron beam vapor deposition and evaporation assembly, designed to provide the utility of three electron beam guns in a single unit, is available from Materials Research Corp. Main application is expected to be in high-speed evaporation of multi-layer electronic circuitry and in electron microscopy where shadowing techniques are important.

In operation of the Model V4-207, the sample to be evaporated is placed into one of three hearths, which are moved under a fixed position filament emitter by manually pushing and pulling the gun. The gun is mounted in a vacuum feedthrough, which will hold vacuums to 10^{-7} torr.

The unit can achieve temperatures in excess of 3,600°C generally within 5 to 10 seconds. Contamination in the film is avoided by using material holders (hearths) that are water-cooled and replaceable.

Circle No. 151 on Subscriber Service Card

Subminiature Transducers

A line of pure platinum subminiature surface transducers, designed for aerospace and industrial applications requiring measurement of temperatures within a range of −435° to 800°F, has been announced by Thermal Systems, Inc.

The units feature a response time of less than 300 millisecs. and a repeatability of ±0.05% under cycling. According to developers, the platinum sensing element is supported, yet "floats" within an envelope having a like coefficient of expansion to the sensor itself. Change in resistance as a function of temperature is in accordance with the Callendar-Van Dusen equation. Nominal resistance values from 50 to 1,400 ohms, at 32°F, are available.

Circle No. 152 on Subscriber Service Card

K-Band Circulator

Raytheon Co. is marketing an X-band circulator that operates on an average power of 100 kw CW. The power level is said to be two times that achieved previously for circulators in this frequency band.

The Model CXH26 has a maximum insertion loss of 0.25 db and isolation greater than 20 db. An input VSWR of 1.10 or less is achieved in the operating frequency band of 7.7 to 8.4 gc. The unit is designed to withstand 20-psig waveguide pressurization; input and output are in the WR-137 waveguide.

Circle No. 153 on Subscriber Service Card

Frequency Discriminator

Parzen Research, Inc., has developed a 1-mc frequency discriminator, the Model 118.

The device accepts an input of 1 mc ±15 cps and generates a dc voltage proportional in magnitude and sign to the difference between the input frequency and the center frequency. Output sensitivity is 0.1v per cps. Linearity of ±1% is achieved for ±5 cps and ±2% for ±10 cps. Provisions are included for setting the zero point of the output to correspond to a center frequency of 1 mc ±2 cps.

Stability of the center frequency (zero output) is said to be greater than ±0.05 cps for any 10°C frequency range. Operating temperature range is 0 to 50°C. Input voltage may vary from 0.5 to 2v. Input impedance exceeds 5,000 ohms.

Circle No. 154 on Subscriber Service Card

Density Measurement Device

Precision Thermometer and Instrument Co. has developed a teflon-lined density measuring device, the Densitrol. The instrument is designed for use with highly corrosive liquids or those where metal-ion contamination presents a problem.

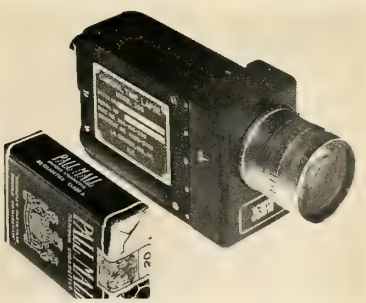
The Model 316SS is supplied with pyrex plummets and tantalum or platinum chains. It measures density values from 0.5 to 3.5 grams/cc. with spans as low as 0.005 grams/cc. Automatic temperature compensation to 110°C is standard; a 230°C limit is available on special order. The standard unit may be used to pressures of 125 psig.

Circle No. 155 on Subscriber Service Card

Time-Lapse Camera

A time-lapse camera with low power consumption for use in Earth-orbiting satellites is available from J. A. Maurer, Inc.

The camera is designed for operation in a closed ecological system and is said to be the only in-flight data gathering device for plant physiology and biological rythmic growth experiments. It uses standard 16-mm film and operation is automatically controlled by two electrically independent command pulses separated in time. Shutter opening is controlled by the leading edge of the first pulse; shutter closing followed



by film transport is controlled by the leading edge of the second pulse. Minimum exposure time is 1/50 second; maximum exposure time is required to be 100 minutes. Lens characteristics are F/1.8, 10-mm focal length, 68-degree field of view. Resolution exceeds 50 lines/mm.

Circle No. 156 on Subscriber Service Card

METTLER

HANDSCHUMACHER

MARSH

KNIGHT

FINLEY

Ruben F. Mettler, Stanley C. Pace and **Edward P. Riley:** Elected to three-year terms on the board of directors of TRW, Inc., (formerly Thompson Ramo Wooldridge, Inc.), Cleveland. The men were also named executive vice presidents of the firm and will continue to have management responsibility for TRW Space Technology Laboratories, TRW Equipment Operations and TRW Automotive Operations, respectively.

Albert G. Handschumacher: Elected chairman of the board and chief executive officer of Aeronca Manufacturing Corp. He was formerly president of Lear Siegler, Inc.

Charles J. Marsh: Appointed vice president-marketing of Milgo Electronic Corp. He was formerly director of marketing analog computing equipment.

C. Raymond Knight: Named vice president and general manager of Arinc Research Corp. **Donald W. Sharp** was named vice president-research and engineering and deputy general manager, and **Joseph D. Ellis** was named vice president of marketing and contracts at the same time.

Thomas D. Finley: Named a vice president of the Sperry Rand Corp.'s Univac Div. He will be in charge of Washington Operations for UNIVAC Defense Marketing.

Roger A. Lakowicz: Appointed director of materiel at HRB-Singer, Inc.

Dr. Arthur C. Cope: Selected to be the first Camille Dreyfus professor in chemistry at Massachusetts Institute of Technology. He is head of the chemistry department there.

John R. Luneau: Elected to the board of directors of Kollmorgen Corp. He is president of Inland Controls, Inc., a Kollmorgen subsidiary.

Edward J. Odlum: Appointed general manager of Kaman Electronic Systems Div. of Kaman Aircraft Corp. He is also vice president and director of Kaman.

Dr. George B. Kistiakowsky: Elected vice president of the National Academy of Sciences for a four-year term beginning July 1. He is professor of chemistry at Harvard University and former special assistant to President Eisenhower for science and technology.

George P. Sampson: Elected vice president in charge of operations for the Comsat Corp. **John V. Friel** has been named director of personnel administration.

V. L. Anderson: Appointed special assistant to the president of Lear Siegler Service, Inc., a subsidiary of Lear Siegler, Inc.

David A. Sundberg: Appointed editor of *Nuclear News,* the publication of the American Nuclear Society. He was formerly editor of *The Atom,* in-house publication of Los Alamos Scientific Laboratory.

Harry G. Earl: Appointed executive vice president of Mechmetals Corp., a subsidiary of Mechmetals-Tronics, Inc.

A. P. Fontaine: Elected chairman and chief executive officer of the Bendix Corp. At the same time, **G. E. Stoll** was elected president and chief operating officer. **M. P. Ferguson** was elected chairman of the newly-organized finance committee.

Alton B. Goehring, Jr.: Elected vice president and controller of Dynalectron Corp.

Warren C. Rush: Named executive assistant to the president of Products Research Co.

Dr. Robert A. Cooley: Joined the research staff of Monsanto Research Corp.'s Dayton, Ohio, laboratory.

Thomas G. Jennings: Elected president and Kenneth F. Hammer, vice president, of Electropac, Inc., a subsidiary of Computer Control Co., Inc.

Gerald J. McCaul: Elected president, chief executive officer and chairman of the board of CompuDyne Corp. Also elected was **Henry R. Murphy** as treasurer.

Robert N. Scott: Elected an executive vice president of American Bosch Arma Corp.

R. J. Hadden: Appointed program manager, nuclear instrumentation and control for the Product Support Equipment Dept. of Westinghouse Defense and Space Center, Baltimore.

James M. Ricketts: Named deputy manager of operations for the Nortronics Div. of Northrop Corp. Named to succeed Ricketts as director of manufacturing was **Raymond A. Schultz.**

John P. Leahan: Appointed director of manufacturing, along with **Frederick M. Seitz,** appointed director of material, for Textron's Bell Aerosystems Co.

Carl H. Haushalter: Appointed manager of the new Space Systems Laboratory at the Electronics and Space Div. of Emerson Electric Co.

John J. Moran: Elected president and chief executive officer of Sigma Instruments, Inc. He was formerly executive vice president of the firm.

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MAY

Symposium on Passive Gravity-Gradient Stabilization, sponsored by NASA's Ames Research Center, Moffett Field, Calif., May 10-11.

International Conference and Exhibition on Nuclear Reactors and Radioisotopes, sponsored by the Canadian Nuclear Assn., Quebec, P.Q., Canada, May 10-12.

National Aerospace Electronics Conference, sponsored by the Institute of Electrical and Electronics Engineers (IEEE) and the American Institute of Aeronautics and Astronautics (AIAA), Dayton, Ohio, May 10-12.

Symposium on Pulsed Neutron Research, sponsored by the International Atomic Energy Agency, Karlsruhe, Germany, May 10-13.

Annual Meeting of Shareholders of the Communications Satellite Corp., Shoreham Hotel, Washington, D.C., May 11.

Purchasing and Subcontracting Seminar, sponsored by the National Defense Education Institute, New York City, May 11-13.

International Conference on the Internal Conversion Process, sponsored by the Atomic Energy Commission and National Science Foundation, Nashville, Tenn., May 11-13.

Eighth National Power Instrumentation Symposium, sponsored by Instrument Society of America, Commodore Hotel, New York City, May 12-14.

Symposium on Signal Transmission and Processing, sponsored by IEEE, Columbia University, New York City, May 13-14.

Fourth Annual Symposium on Government Contracts and Administration, sponsored by the National Contract Management Assn., Airport-Marina Hotel, Los Angeles, May 14-15.

56th National Meeting of the American Institute of Chemical Engineers, Hilton Hotel, San Francisco, May 16-19.

27th Annual News Conference of the Aviation/Space Writers Assn., Western Skies Hotel, Albuquerque, N.M., May 16-22.

24th Annual Conference of the Society of Aeronautical Weight Engineers, Brown Palace Hotel, Denver, May 17-19.

International Conference on the Application of Computing Methods to Reactor Problems, sponsored by the American Nuclear Society, Argonne National Laboratory and European Nuclear Energy Div., Argonne, Ill., May 17-19.

International Conference on Components and Materials Used in Electronics Engineering, sponsored by the Institution of Electronic and Radio Engineers and Institute of Electrical and Electronics Engineers, London, May 17-21.

International Telemetering Conference, sponsored by the International Foundation for Telemetering, Washington, D.C., May 18-20.

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Honor Without a Profit

THE INVESTIGATION of Aerospace Corp. by the Hardy subcommittee thus far has turned up some interesting trivia but has yet to come to grips with the real issues involved.

We are fascinated to learn that a prominent Washington newsman was on the company payroll, that the public relations director got a 20% annual salary bonus if he didn't create a "major disturbance," and that one employee got $2,361 relocation expenses on a move which took him further away from the plant than before.

But interesting as these tidbits are, they fail to add up to any really significant evaluation of the role of Aerospace Corp. Efforts by witnesses to stress the real contributions of the firm have been lightly treated by the subcommittee.

It is quite fitting that the Hardy subcommittee should probe into the operations of Aerospace. The firm was a creature of Congress from the first and it is proper that Congress should take a close look at its five-year-old child.

But the emphasis of the investigation seems to us to have been in the wrong areas. There has been all too much concern with the salaries paid to Aerospace executives and employees. The committee seems shocked at the extravagance of these. Yet it has been no secret from the beginning that one of the reasons for the existence of Aerospace, and other not-for-profit organizations such as Rand and Mitre, has been to sidestep the restrictions of government salary scales.

Aerospace provides a means by which Air Force can compete salary-wise with industry for high-priced scientific and industrial talent. Its salary scale is attuned to industrial levels, not government levels, and the corporation keeps a close eye on what its profit-seeking competitors (in the recruitment sense) pay their personnel.

In questioning by a Senate subcommittee four years ago, Najeeb Halaby, who was secretary-treasurer of Aerospace prior to his appointment as Federal Aviation Administrator, stated:

"It is hard to get people to work for the government instead of for capital gains or bonuses."

He agreed with the subcommittee's contention that the government-established private corporation was a "gimmick" to get around the government salary ceiling, but he declared it was one that could be defended as being in the national interest.

We believe that this is true. It is necessary for the Air Force to have objective advice and consultation on a number of important matters. It is necessary that the people who do this be of the highest caliber. The proper concern, then, is with a definition of Aerospace's role and the question of whether it is fulfilling it properly. There were more reasons for the establishment of Aerospace than salary scales.

To understand these fully, it is necessary to take a look at the reasons for creation of the company in the first place. It will be recalled that Congress, and a number of members of the missile/space industrial community, became disenchanted with the role Space Technology Laboratories was playing in the ballistic missile program. STL had been established in 1957 as a wholly owned but independent subsidiary of Thompson Ramo Wooldridge. Despite restraints imposed by the Air Force which prohibited TRW bidding on any hardware work for which STL had systems responsibility, suspicion about the relationship was voiced openly. TRW, for its part, was not too happy with the competitive handicap under which it was blocked out of a lucrative field.

The Holifield subcommittee of the House Committee on Government Operations looked into the situation. Out of that probe came the decision to create Aerospace Corp., which was founded as a non-profit firm in June, 1960.

There was little doubt about the need for the organization. The Secretary of the Air Force in 1959 appointed a committee of outside scientists and industrialists, headed by Dr. Clark B. Millikan of California Institute of Technology, to study the situation. That group, among its other findings, declared that "the Air Force must, in some form, continue to have access to the kind of high competence supplied by STL."

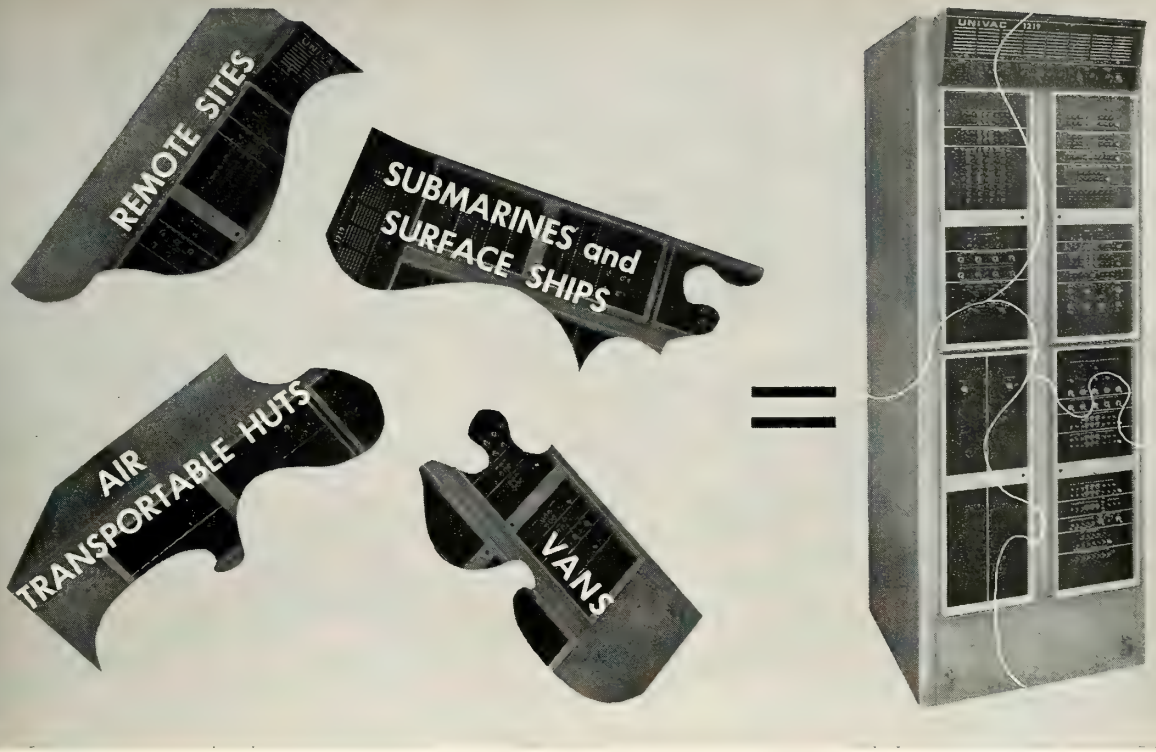
THE AIR FORCE does not wholly possess in-house the wide-scale scientific and technical competence necessary for drawing up missions, requirements and specifications and for evaluating proposals when they are returned from industry, either solicited or unsolicited. Aerospace is the arm to provide this. It also provides broad, as distinguished from detailed, systems engineering and technical direction. A major question for Congress then should be the one of how well Aerospace has been carrying out its assigned task. Gen. Bernard Schriever of Air Force Systems Command feels it has been doing an excellent job, and his comments should not be taken lightly. The proof lies in the record of the various programs assigned to Aerospace. That record is a good one.

Another question to which the committee might well devote detailed attention is the one of how competitive Aerospace is with profit-motivated industrial firms. True, it is prohibited from engaging in the production of hardware. But today there are many industrial firms which depend for their existence on research and development, not the manufacture of hardware. What steps has the Air Force taken to assure that this grey area between non-competitive and competitive work is carefully monitored?

We find it wryly amusing that a group of Congressmen sitting in the obscenely ornate new Rayburn Office Building should criticize Aerospace for building offices for high-paid scientists which are on a much more modest scale. But we do believe the committee should raise the question of whether a not-for-profit corporation such as Aerospace should have a completely free and unmonitored hand in the spending of money it takes in as fees. The level of these fees also should be investigated.

There are serious questions to be answered about Aerospace. But they have not yet been asked.

William J. Coughlin



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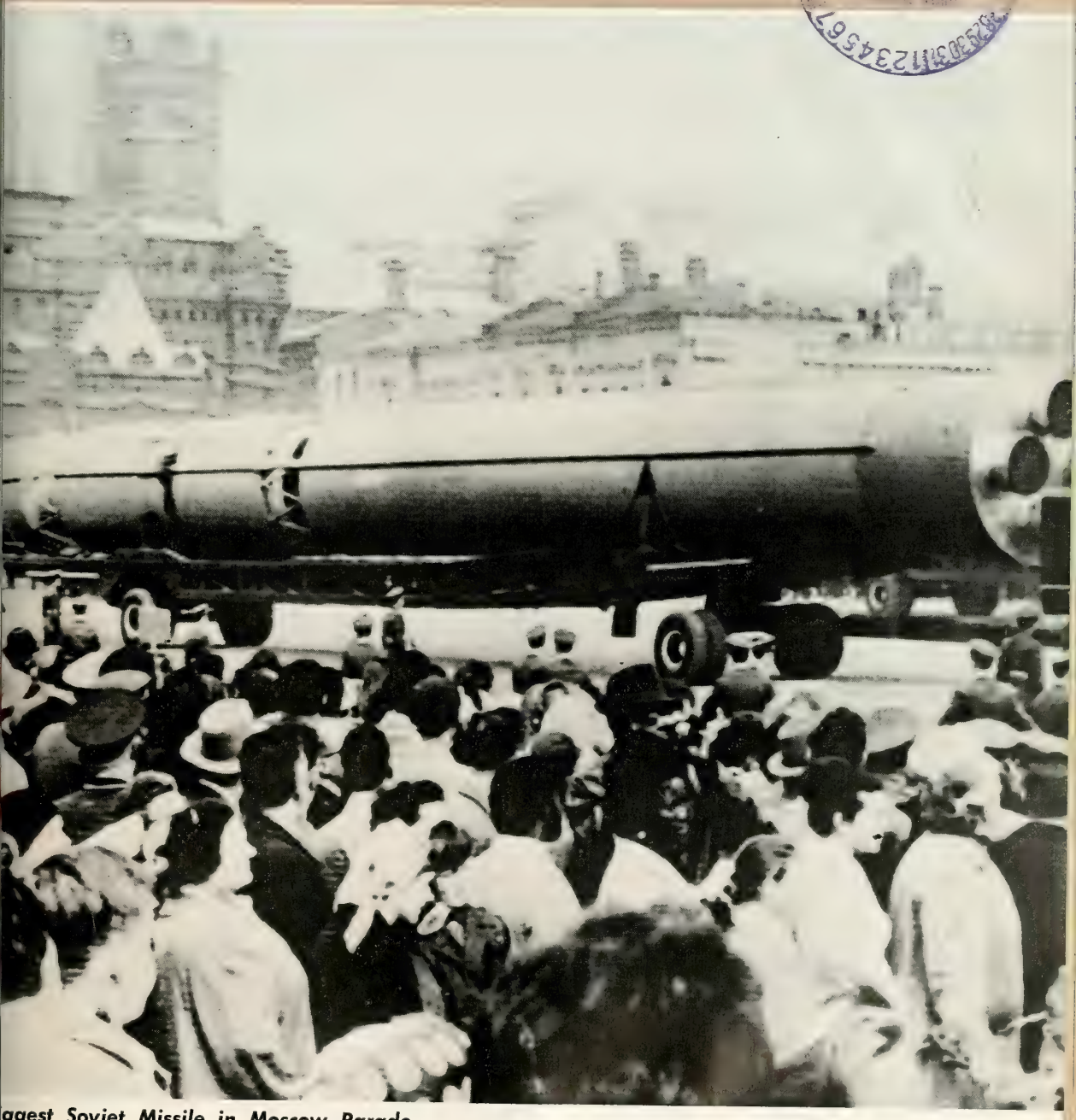

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Volume 16, Number 20 May 17, 1965

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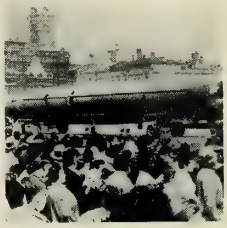

Soviets say this three-stage ICBM, one of three new weapons shown for first time in Moscow VE-Day parade, is solid-fueled and "similar" to boosters used in manned shots. U.S. observers doubt the rocket uses solid propellant. See story, additional photos, on p. 16.

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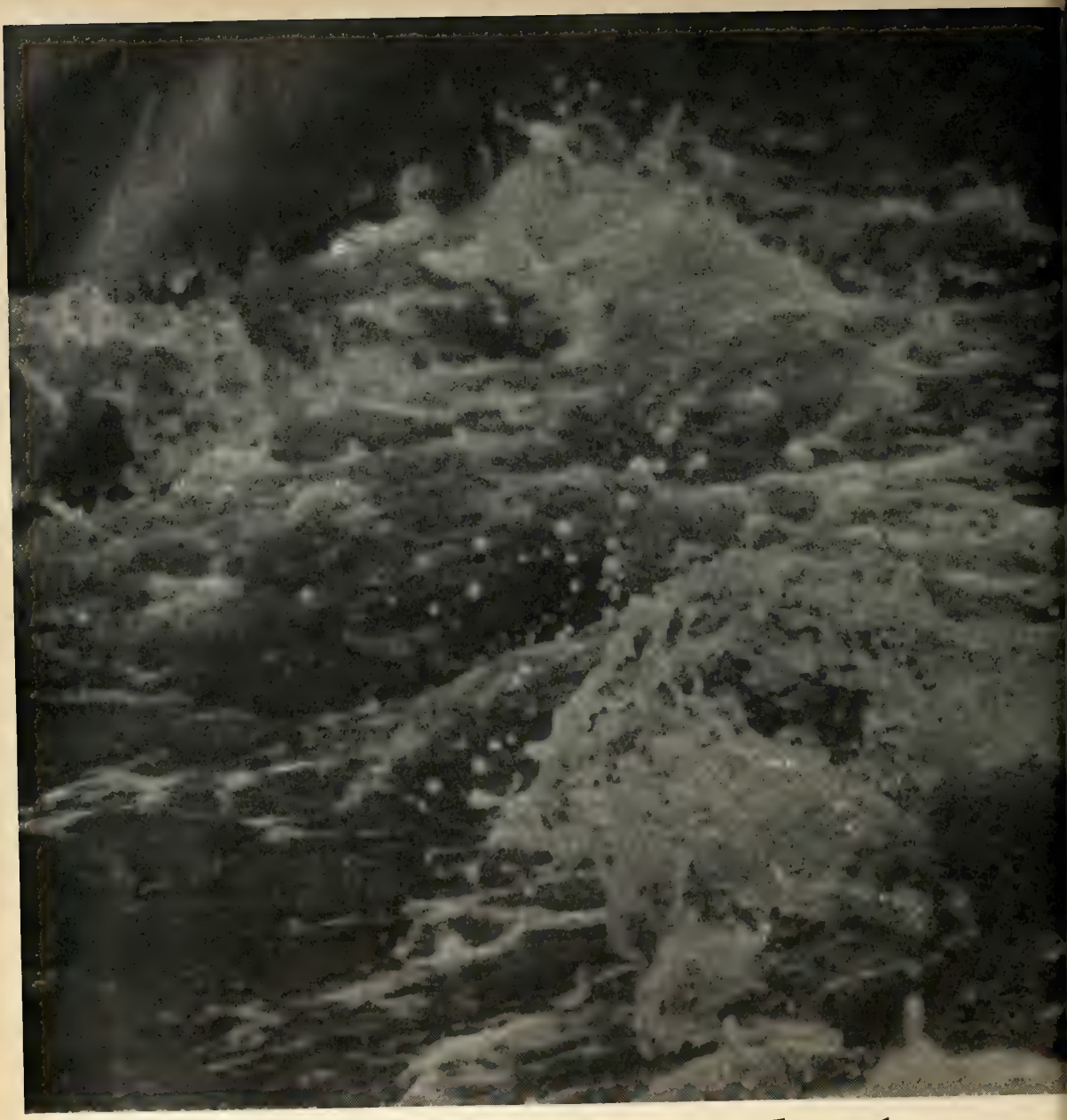
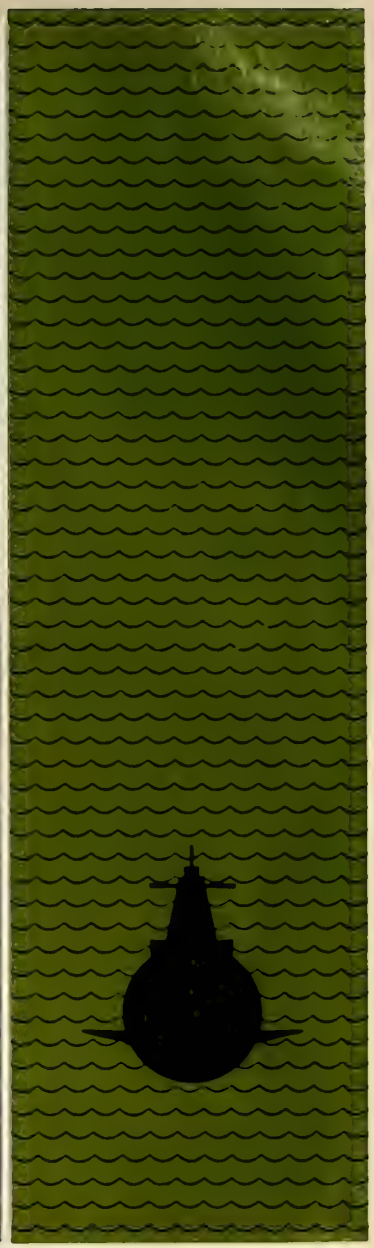


"He maketh the deep
to boil like a pot..."



This was Anti-Submarine Warfare (ASW), Old Testament version (*Job* 41:31).

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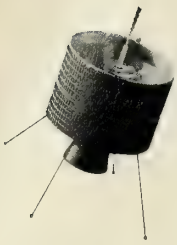

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letters

Apollo Gamble

To the Editor:

Your editorials have always been some of the best and most interesting commentaries on current aerospace events and issues, but the "Moon Struck" (April 12) offering fell considerably short.

The "poppycock" you referred to in accusing NASA of suggesting "that the President, Congress and the American people have embarked on a $20-billion manned lunar landing program with the question of whether the Moon surface was smooth enough to land on still unanswered" is far from a joke. This is the greatest gamble—or, if you will, calculated risk—in the history of the nation. Witness not only the *Ranger* and *Surveyor* programs as evidence of our ignorance, but the initiation of the *Lunar Orbiter*—this *long after* the LOR decision and the procurement action on CSM and LEM.

In addition, we can't ignore the diverse speculation and sometimes sharp disagreement between Dr. Bruce W. Hapke and Dr. Thomas Gold of Cornell; Dr. Zdenck Kopel of the University of Manchester, England; Dr. Gerard B. Kuiper of the University of Arizona; and Dr. Eugene Shoemaker, recently with NASA Headquarters. Seldom have these men agreed on the probable texture and composition of the lunar surface, and recent radar studies at Cornell suggest lunar dust as deep as three meters. If this is true, the LEM crew may face not only a difficult but perhaps an aborted mission, especially when we consider the problem of static charge and the accumulation of dust on both stages of the vehicle.

Thus the case for *Surveyor* and *Orbiter* is indeed a strong one, and Dr. Newell does not have 'light regard" for the manned landing, since his programs obviously are necessary before that landing can even be attempted. Paraphrasing Churchill, "Never in the history of man has so much been gambled by so many knowing so little."

R. E. Wylie
Decatur, Ill.

Lunar Dust Debate

To the Editor:

Re "Lunar Surface Controversy Rekindled" (M/R, April 26, p. 16), it is difficult to imagine how the mechanisms proposed by the lunar dust surface theorists would cause—or even permit—such a condition to exist. The criteria for diffusion bonding are well known: (a) solid surfaces of reasonable chemical similarity in contact range, (b) absence of absorbed gas species, (c) temperature, (d) pressure and (e) time. The big inhibitor on Earth is the gas, and considerable work is being done to prevent welding of surfaces in space in the absence of it.

Without surface water and atmosphere, erosive processes for dust formation do not exist on the Moon as on Earth. Therefore, particles will be principally from volcanic and meteoritic causes. All the criteria for bonding them are satisfied, and what is lacking in temperature (during the lunar day) and pressure (gravity) will be made up by time. Certainly, any extraneous dispersing forces—such as may be due to electrostatic potentials—will be instantly dissipated in the essentially solid, mineral environment.

The language used by dust proponents, "I'm scared of a manned lunar landing," suggests a motive—that they are opposed to manned space exploration on the vague moralistic basis that it serves no human purpose. This is the language that has always been used by status quo science. Since great humanitarian causes have never sold well to the public, man's excess ingenuity has tended to be spent in self-destruction. Perhaps they feel that is a better purpose?

Vernon R. Gutman
Saratoga, Calif.

To the Editor:

To me the most unusual feature of the recent lunar photos is the smoothness of the steep walls, whether mountain or crater sides. While the surrounding areas are often riddled with craters, these steeper walls appear smooth and unmarked. Could the explanation be deep dust that slides and and covers the craters of impinging meteors? Those who have had the experience of walking in mounds of wheat or similar loose material will remember that footprints (craters) are left on flat or gently sloping surfaces, but when the sides get very steep no footprints remain. Other explanations may exist, of course, such as the possibility that the steep slopes were formed at a later age than the majority of craters, or that the film was over-exposed on the highlighted slopes. If due to dust slides, the dust must be very deep.

T. M. Morse
Santa Maria, Calif.

Short Thrust

To the Editor:

I have just finished reading your May 3 article entitled "Million-Pound-Thrust Hybrid Proposed." Very interesting. But I soon wearied of reading "million-pound-thrust" and "million-lb.-thrust" and "million-lb.-thrust class" and "million-lb.-thrust," etc.

For many years we've had cfm, psi, fps, gpm, and even etc. It appears reasonable to now introduce a little fellow called mpt. Of course this type of article would become shorter, but then there would be room for another one.

Of course the "m" is for mega—and there would be fractionals, for example, 1/20 mpt (50,000-lb.-thrust).

William A. Koch
Aberdeen, Md.

We just may.—Ed.

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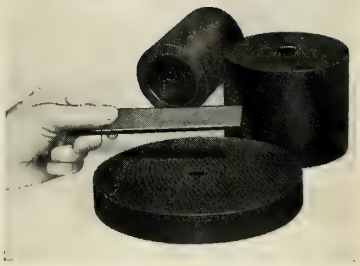

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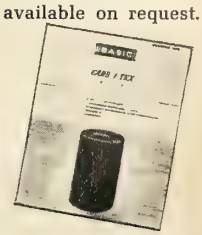

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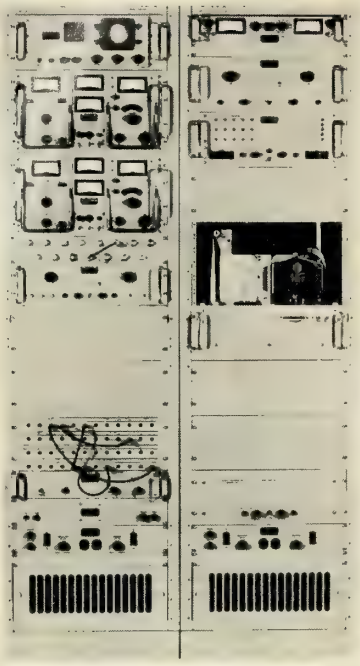

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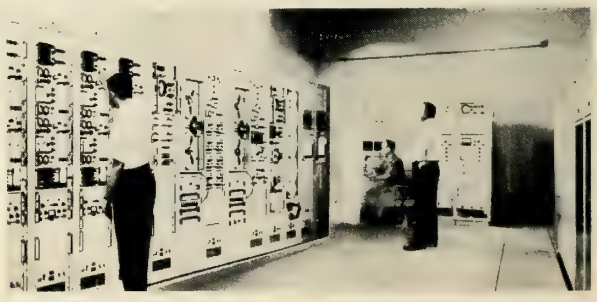

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The Countdown

WASHINGTON

MOL Report Lagging Slightly

Air Force wasn't able to meet the May 15 target date originally set for presentation to DOD of the results of studies of *Manned Orbiting Laboratory*, spokesmen acknowledge. No new, firm date has been set, but informed sources intimate the slippage will be a matter of days, rather than weeks or months.

Bisplinghoff Denies Resignation Plans

There are recurring reports that Dr. Raymond Bisplinghoff, NASA associate administrator for advanced research and technology, will resign his post in order to succeed Dr. C. Stark Draper as director of MIT's Guidance and Navigation Laboratory. Bisplinghoff officially denies the rumors, however, and says he has no present plans to leave the space agency. Draper is approaching mandatory retirement age.

Sixth Centaur Slips Further . . .

Next *Centaur* launch has slipped another month—into July. Rebuilding of Pad 36A at Cape Kennedy, damaged when *Atlas/Centaur 5* was destroyed, apparently is the major cause for the slippage. The seventh *Centaur* attempt, with its *Surveyor* engineering model payload, is still scheduled for October of this year.

. . . And Fire Is Twice Deferred

The Project *Fire* launch is now rescheduled for May 24. Delay from the planned May 4 shot was caused by problems with a telemetry encoder in the re-entry package. When that was fixed, a technical malfunction was discovered in the velocity package and it was returned to its manufacturer, Ling-Temco-Vought, for repairs.

Lance Production Prospects Bright . . .

Army's *Lance* missile, now under development, may be due for early production funding. In recently released testimony before the House Subcommittee on Defense Appropriations, Defense Secretary McNamara said that "if the tests are as successful as it now appears they will be, I suspect we will be asking in the FY 1967 budget for production money for deployment of the system."

. . . While MMRBM Picture Stays Foggy

Bewilderment over the *Mobile Medium-Range Ballistic Missile (MMRBM)* has been revived in Congress by McNamara, who now takes the position that the lawmakers' elimination of funds for it was "a serious mistake." Most Congressmen had a distinct impression that the cuts were made because the Secretary himself didn't fully support the program—or, if he did, failed to come and tell them so. This year, he told the House Appropriations Committee, "I am softening you up for a year or two from now . . . if circumstances still appear to justify that insurance, we will come back and ask for it again."

NASA Confirms Recruiting Office Cutback

Space Agency has announced it is closing its recruiting offices in Santa Monica, Calif., and Dallas, Tex., and moving its New York office to Boston. Changes follow review of recruiting activities to determine whether to retain the offices now that hiring needs have leveled off, the agency reported. Announcement followed an earlier M/R report, denied by NASA, that it was considering closing some offices.

Sea-Launch Rocket System Ready for Use

Recently completed *Hydra-Iris* development program has provided what is perhaps the first sea-launch rocket system available anywhere for operational use, according to the Navy, which says it does not itself have any plans to use it. Project Hydra research, which developed the two-stage, 1,700-lb. *Hydra-Iris* rocket, now will investigate floating vertical-launch methods for rockets up to ICBM size. With feasibility of floating launch proven, the system has been made available to the scientific community for launching payloads directly into any desired location to study phenomena not accessible through land launches.

INDUSTRY

Martin Wins RADA Development Job

Martin-Orlando has been awarded an $11-million Army development contract for work on the RADA (random access, discrete address) communications system. The digital communications system will be produced for Army and Marine Corps deployment. Contract, awarded by Army Electronics Command at Ft. Monmouth, N.J., will be completed in three phases over a total of 32 months.

INTERNATIONAL

DR Trouble Moves, Delays COSPAR Meeting

Apparently because of concern that U.S. delegates might be harassed by Buenos Aires students protesting American action in the Dominican Republic, the sixth international space symposium of COSPAR (Committee on Space Research) was moved 200 miles south of the Argentine capital to the resort city of Mar del Plata. The shift caused a delay in the meeting, involving 320 delegates from 33 countries, from its scheduled opening on May 10.

Japan Plans All-Japanese Launching

Highlighting national reports at the COSPAR gathering was Japan's disclosure that it would launch its own satellite with its own launch vehicle within the next three years. K. Maeda, the chief Japanese delegate, told M/R a four-stage, solid-fueled rocket will be used, with the *Mu* rocket as first stage. The satellite, to be employed solely for scientific research, will weigh between 50 and 100 kilograms and be sent into a 500-1,000-km orbit.

Soviets Candid in Space Money Matters

A Russian scientist speaking at a recent space symposium in Chicago revealed that he and his colleagues suffer just as NASA does from budgetary restrictions. Queried as to why the USSR didn't launch more than one spacecraft (*Zond II*) during the 1964 Mars opportunity, he replied simply, "we couldn't afford it." As for the U.S. program, he told U.S. scientists attending the meeting: "You have done well. You have passed your exams, but I think we still have things to teach you."

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DOD-GAO Friction Probed

Differences of opinion between the Defense Dept., defense contractors and the General Accounting Office have been brought to a head and are being thoroughly aired by the House Government Operations Military subcommittee under the chairmanship of Rep. Chet Holifield (D-Calif.).

The investigation was apparently spurred by the large number of dissenting opinions lodged by DOD and contractors over GAO findings in auditing defense contracts.

In opening testimony, Assistant Secretary (Installations and Logistics) Paul R. Ignatius told the subcommittee that there are several basic areas of disagreement between DOD and GAO.

He also pointed out that the number of GAO reports has increased substantially in the past three years, from 206 in 1962 to 544 in 1964. "We do not believe that the increase in the number of reports is a barometer of the number of deficiencies in procurement," he said. Ignatius quoted Secretary of Defense McNamara, who said, "these deficiencies are much more easily recognized after the fact than before."

One of the main areas in which disagreements occur lies in the question of when and under what conditions a voluntary refund should be sought from a contractor, Ignatius said.

GAO makes recommendation that a refund be obtained when it feels that costs are "unnecessary, excessive, or unwarranted." However, DOD has disagreed many times with GAO's findings because it did not concur with the facts as stated by the GAO, or because DOD concluded that "the circumstances did not meet the conditions specified by DOD policy."

Ignatius pointed out that DOD's policy is that the government, like any private individual, is bound by the agreement which it enters into. Unless there is a claim of legal right, the DOD will seek a price adjustment only in extraordinary cases, he said.

Another example of a difference over a case was cited by Ignatius, who said that GAO decided, after a contract had been fully performed (for runway construction at Andrews AFB, Md.) that the contract was illegal and took steps to withhold payments. The Assistant Secretary termed the action "inappropriate," saying that contractors should have reasonable assurance that they are holding binding contracts with the Government.

The difference between GAO and DOD view on this was characterized by Ignatius as "a difference between the cost-type approach to defense contracting and the fixed-price approach."

Ignatius said that the difficulty with cost-type contracts is that they offer no incentive to the contractor to make any real effort to reduce the amount of costs incurred in the performance of the contract.

GAO has, in a number of instances, he said, criticized use of fixed-price contracts or those in which contracts were switched from cost-type to fixed-price. However, he said, DOD has found great savings in the long run by eliminating most of these very cost-type contracts.

In a number of reports, GAO has criticized DOD on the basis that unnecessary costs have been incurred because the military departments permitted contractors to purchase their own equipment and components, where GAO felt it would have been more economical for the Government to purchase the items directly and provide them as GFE to the contractor.

However, the Assistant Secretary said, there are real dangers in carrying this policy too far, including criticality of the item to safety or military effectiveness, stability of design, effect upon the prime contractors' performance responsibility, effect on production schedules, and extra administrative costs to the government.

On the question of whether U.S. government data processing equipment should be furnished to contractors, rather than allowing the contractor to lease his own equipment, DOD disagreed with the 29 reports GAO made.

Defense contractors have strongly opposed setting up a government computer pool as suggested by GAO, on the grounds that the nature of the work demands that the computers be available instantly, and be manned by their own trained personnel. DOD also pointed out that it feels it "essential in a system of free enterprise that such decisions not be imposed by the Government, but that they be made by contractors, subject to appropriate Government review."

DOD also announced to the subcommittee that it is setting up, starting July 1, a Defense Contract Audit Agency, which will consolidate all the activities handled previously by the service auditing functions. It also will be charged with reviewing GAO reports.

Aerospace May Lose Fees

The House Armed Services Special Investigating subcommittee, chaired by Rep. Porter Hardy (D-Va.), is considering action to eliminate the payment of fees to the Aerospace Corp. for work performed for the government.

The action would insure that all finances of the company would come under the direct supervision of and require authorization by Congress. Failure of Aerospace to give information on use of the fees it accumulated during the years of its existence was blasted throughout hearings by the subcommittee, both by Congressmen and Air Force officials.

Another likely action is that the corporation will not be authorized to handle construction of its own facilities. Rep. Hardy indicated that it might be a good idea to write such a clause in the military construction bill, now being considered by the House Armed Services Committee. In effect, this would force the Air Force to ask for money from the Congress to construct facilities for Aerospace Corp., and make such buildings government-owned property.

Comsat Stations Approved

Communications Satellite Corp. is expected to act immediately on construction of ground stations for its global communications system following a favorable ruling by the Federal Communications Commission.

After nine months of consideration, the FCC temporarily bypassed objections of the communications common carriers (M/R, Nov. 30, p. 136) last week and granted Comsat sole responsibility for design, construction and operation of three initial U.S. ground stations. These are to be based in the northeastern and northwestern parts of the U.S. and in Hawaii. Comsat already has land options for a ground station site in Washington state, a spokesman said.

The interim policy set by the FCC is limited to the "critical early years" of the basic system—two years from

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the date of license unless modified by the Commission—and does not apply to a possible station in the southeastern part of the U.S. It also contains provisions that would allow the common carriers to challenge the ruling and possibly prolong the issue.

At the same time, Comsat announced that it is no longer considering the medium-altitude random-orbit system as a basis for its global communications network.

Instead, the corporation will seek proposals for development of a satellite that can be used in a synchronous orbit or a phased system at any altitude between 6,000 miles and synchronous orbits, Joseph V. Charyk, president, told a Comsat stockholders meeting last week.

In fact, Radio Corp. of America—which has been working on a random-orbit system for Comsat—has already proposed a modification to its design, Charyk said. The modification would incorporate an ability to initially position the satellites with respect to each other.

Development of these variable-orbit satellites would begin soon on a schedule that would permit full global deployment by late 1967, said Charyk.

F-111 To Get Added Missile

Top Air Force and Navy project officers in the bi-service F-111 aircraft program have told MISSILES AND ROCKETS that introduction of another air-to-air missile system to augment the *Phoenix* missile now under development for the Navy's F-111B is "a must" and "inevitable."

Demand for such a weapon apparently is not related to problems in the early stages of *Phoenix* development, but reflects a need for a weapons system mix that would include, in addition to the long-range *Phoenix*, a missile of shorter range, which would be used in limited-war or other closely confined operations calling for visual identification of target aircraft (COUNTDOWN, M/R, May 10, p. 7).

Leading contender for the add-on weapon system appears to be the Raytheon *Sparrow III*, although other missiles are likely to be considered, according to project officers.

Apollo Escape Test Set

Fourth test of the *Apollo* boilerplate launch escape system is scheduled at White Sands Missile Range no earlier than May 19, NASA has announced.

A *Little Joe II* rocket will boost the boilerplate number 22 to an alti-

tude of 112,000 ft., where the *Apollo* launch escape subsystem will be fired. The escape motor will carry the spacecraft to a peak altitude of about 175,000 ft. before predicted impact about 110 miles uprange.

For the first time, the boilerplate will incorporate a jettisonable forward heat shield to be separated from the Command Module by thrusters prior to parachute deployment.

Two more abort tests of the escape system are planned for this year.

Gemini Payload Increased

Up-rating of the *Titan II Gemini* launch vehicle booster engines will permit a 100-lb. payload increase on future flights.

Manned Spacecraft Center *Gemini* Program Manager Charles W. Mathews, detailing results of the *Gemini/Titan-3* mission, said that "first-stage engines, running hotter than normal, are giving us more performance than we expected."

He explained that the pitch program in the launch vehicle trajectory is being revised, lofting the *Titan II* slightly to take advantage of the higher performance that has been demonstrated consistently in all three *Gemini* launches.

Mathews also said that the count will be shortened during *GT-4* as a result of running about 30 min. ahead of schedule during *GT-3*.

Two unexpected findings were made in the post-flight analysis: liftoff was undetectable to the astronauts, and the noise inside the spacecraft during the boosted portion of flight was much less than was simulated on the ground. Mathews said the crew will be informed of liftoff to alert them to critical abort functions that may occur after this time.

SA-8 Launch Nears

NASA plans to launch the second *Pegasus* meteoroid technology satellite from Cape Kennedy no earlier than May 25.

The satellite, an advanced version of *Pegasus I*, launched successfully on Feb. 16, will gather information on the frequency of meteoroids in near-Earth environment.

The 1½-ton spacecraft will be launched aboard a *Saturn I (SA-8)*, the first to be built by Chrysler Corp.

Shots of the Week

A successful fourth start in space marked the fourth launch of *Titan III-A* at Cape Kennedy, May 6. The final start sent the transtage from a circular orbit closely approximating the intended 1,500 n. mi. to an orbit with a 2,015-mi. apogee and a 1,500-mi. perigee.

As in the Feb. 11 launch of *Titan III-A* (M/R, Feb. 22, p. 21) another Lincoln Laboratory experimental communications payload was successfully injected into orbit, following the third start of the *Titan III-A* transtage motor in space. This time, however, the satellite's own injection rocket operated satisfactorily, injecting the *LES-2* vehicle into its ultimate orbit with a 8,009-n. mi. apogee and a 1,492-mi. perigee. Period is 309.9 min.

Some 40 secs. after the separation of *LES-2* from the transtage, a second bonus payload, a 75-lb. aluminum sphere 44.5 in. in diameter, was released. The sphere remains in a 1,500-mi. circular orbit. Its diameter was chosen to provide a projected area of exactly one square meter. Thus, in calibrating radars by checking reflected beams, Earth stations will be working in the unit of measurement commonly used to express the reflecting strength of targets.

The opportunity for testing a magnetic system for spin-axis control to aid thermal balance in the *LES-2* satellite will be exploited fully. Because the satellite injection rocket failed in the Feb. 11 launch, the *LES-1* satellite remained in a circular 1,500-mi. orbit and failed to attain the elliptical orbit achieved by *LES-2*.

- The Dept. of Defense Advanced Research Projects Agency announced on May 7 that the high-acceleration experimental missile, *HIBEX*, was successfully launched from the White Sands Missile Range, N.M., on May 1. Shot was second success for *HIBEX*
- After weeks of delay, the Air Force successfully launched a *Minuteman II* ICBM from Cape Kennedy May 7.
- In addition to its *Lunik V* Moonship (p. 14), the Soviet Union on May 7 launched *Cosmos 66*, a scientific satellite.
- The Air Force launched a *Minuteman* ICBM from Vandenberg AFB, Calif., May 11, the 90th *Minuteman* to be fired from Vandenberg.
- An Air Force *Blue Scout* on May 12 carried aloft the third in a series of five cosmic radiation experiments from Cape Kennedy. The 46.5-lb. payload, built by the Air Force's Cambridge Research Labs, was identical to experiments launched from the Cape March 30. Purpose of the flight was to learn more about the distribution of energy in the inner radiation belt. Early information indicated that telemetry was being received.

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Atlas Launch Vehicle To Be Uprated

Approved by NASA and DOD, program is expected to begin in July, require 18 months' development and cost $15 million

by Hal Taylor

UPRATING of the *Atlas SLV-3X* booster has been approved by NASA and DOD, and the first launch is now scheduled for late 1967.

The booster—with first-stage thrust of 350,000 lbs. and sustainer engine thrust of 65,000 lbs.—will be used for all NASA *Atlas/Agena* and *Atlas/Centaur* missions.

Thrust of the current *Atlas* is 300,000 lbs. in the first stage and 57,000 lbs. in the sustainer stage. General Dynamics/Astronautics is prime contractor for the *Atlas*.

The uprating program will cost about $15 million and have a development period of about 18 months.

It was approved last week by NASA Associate Administrator Dr. Robert C. Seamans, Jr. and Director of Defense Research and Engineering Dr. Harold Brown. Work is expected to be started about July 1 of this year.

NASA expects to launch 10 to 12 of the new vehicles per year, beginning with the launch of the eighth *Surveyor* spacecraft late in 1967. The Air Force currently has no plans to use the *SLV-3X*. It plans to rely on its new *Titan III-X* booster for military missions from the Western Test Range.

The uprating will be achieved by having a constant diameter of 10 ft. in the fuel tanks and by increasing their length by 53 in. This will provide 15,000 lbs. of additional LOX and 7,000 lbs. of additional fuel. A resetting of the gas generator and the use of a *Saturn I* injector will also provide a 4.8-sec. increase in specific impulse in each first-stage engine.

The mode 2 turbine has been used successfully in latter stages of the *Atlas* missile program.

In addition to *Surveyor*, other NASA programs which probably will use the new *Atlas* are the *Lunar Orbiter, Applications Technology Satellite (ATS)* and later versions of the *Orbiting Astronomical Observatory (OAO)*.

● **New vistas**—The uprating will result in a sharp increase in payload performance when used with both the *Agena* and *Centaur* upper stages.

Combined with *Centaur*, it will increase the escape payload capability about 600 lbs. For Earth-orbit missions, the payload weight can be increased from 10,000 to about 11,000 lbs. The escape payload increase will be especially important to the *Surveyor* program when the later spacecraft—beginning with the eighth in the series—will weigh about 2,650 lbs. compared to the 2,100-lb. weight of the earlier version.

The increase in the *Atlas/Agena* payload is just as striking. For example, it will add about 450 lbs. to the current 950-lb. limit for escape missions. In a 300-mi. orbit, the *Atlas/Agena* payload will jump 1,500 lbs. from the current payload of 5,950 lbs.

NASA officials still have not worked out details of how the *SLV-3X* will be procured, but a meeting on the subject will be held with Air Force officials in the near future. NASA is currently satisfied with the work the Air Force has done in procuring standard *Atlases* for the space program, and if the Air Force is willing, probably will extend it.

● **No AF need**—Air Force reluctance to use the *SLV-3X* stems in part from its lack of *Atlas* booster missions from the Eastern Test Range. Currently, Air Force missions from the Western Test Range do not require higher payload weights than can be lifted by the standard *Atlas*, which they are using. When heavier payloads are needed, the requirement is expected to be met by the newly approved *Titan III-X*. Funds for a Western Test Range launch pad for that booster are included in DOD's Fiscal Year 1966 budget.

The space agency does not have any plans to use the *Titan III-X*. It would require the modification of a *Titan II* pad at Cape Kennedy at a cost of $7-8 million, and officials believe this is prohibitive. NASA also likes the *Atlas* reliability record. ■

Lunik V Fails, but Emphasizes Gap

THE SOVIET UNION is apparently ahead of the U.S. in the race to soft-land a spacecraft on the Moon despite the failure of *Lunik V*.

The Russian spacecraft—launched May 9—ceased transmitting when it impacted on the Moon at 3:09 p.m. May 12. The impact was about five minutes earlier than scheduled and apparently resulted from faulty performance of the retro-rocket system.

U.S. officials expect the Russians to make more attempts to soft-land on the Moon. The official Russian communique pointed out that *Lunik V* provided valuable data for the technology required for a successful landing, implying future flights.

The U.S. will not attempt to make a similar flight until October, when an engineering test model of the *Surveyor* will be launched. This spacecraft, and the next three in the series, will carry only television cameras. The prime objective of these flights is accomplishment of a successful mid-course guidance maneuver. If the guidance maneuver is successful, the spacecraft will continue to the Moon. There are few NASA officials, however, who expect the first flights to be successful. Furthermore, the first four spacecraft will carry no scientific experiments to gather data during the flight to the Moon.

The Soviet Union announced that the 3,500-lb. *Lunik V* was launched from an orbiting mother vehicle. The objective of the flight, according to the Russians, was a soft lunar landing. They reported May 11 that a successful mid-course guidance maneuver had been made and that the spacecraft, oriented by the Sun and Earth, would impact in the Sea of Clouds area near the South Pole.

U.S. officials reported the next day that this country had tracked the spacecraft and that it had impacted on the Moon. On the same day, the Russians reported that the spacecraft had hit the prescribed landing area. They did not claim a successful landing, however. The communique said that "During the flight and the approach of the station to the Moon, a great deal of information was obtained which is necessary for further elaboration of a system for a soft-landing on the Moon's surface." Experts believed that if a soft landing had been achieved, the Russians would have been quick to let the world know about it.

$90-Million NASA Request Cut Seen

Anticipated reduction considered light; Senate committee favors delay of SNAP 8 funds, but joins House in voting extra money for 260-in. solids

by Heather M. David

CONGRESS IS AGAIN letting the National Aeronautics and Space Administration off fairly lightly with total reductions this year in the Fiscal Year 1966 request now settling around $90 million.

The situation is somewhat confused at this point, since the House has passed the appropriations bill before the final authorization figure has been determined. However, since the House Appropriations Committee figure is usually the lowest of all the various actions which must occur before the budget becomes final, its recommendation that $100 million be cut from the original request of $5.26 billion bodes well for the agency. Unless the Senate Appropriations Committee reverses its usual practice of restoring part of the House cut, the $100 million would appear to be the maximum the agency must bear.

The Senate Space Committee also has completed its action upon the bill, with the recommendation that the agency receive $5,196,826,350. This amounts to $12,981,500 more than the House voted, and $63,173,650 less than NASA's request.

In completing this action, the Senate committee cast a pall over the future of the M-1 program, recommended postponement of funding for SNAP-8, and upheld the House in voting extra funds for the 260-in. large solid rocket motor development program.

Funds for the three programs were not requested by the President in the FY '66 budget. The House voted to fund SNAP 8 at $6 million, M-1 at $15 million, and big solids at $6.2 million.

In not funding the SNAP 8, the Senate Space committee said that it felt that there was a need for the program, but that reprogramming actions will carry funding through a 10,000-hour test of components. After this is completed, the committee feels, consideration should be given to picking up funding again.

Although the 260-in. solid program receives $6.2 million under the Senate and House bill for Phase II work, the Senate committee will stipulate that Congress must be consulted after Phase I firings are completed, before proceeding to Phase II.

- **Manned spaceflight**—The Senate Space committee voted a cut of $24 million in the *Apollo* program, compared with a cut of $30 million made by the House. Total funding approved by the Senate committee was $2.9 billion. The Senate also granted full funding of $10 million for advanced missions, and $242.1 million for *Gemini*, as did the House.

- **Space Sciences**—The Senate voted all funds for the *Orbiting Geophysical Observatory* program, as opposed to House action which trimmed $5.4 million. However, the Senate went along with House action in cutting the *Orbiting Astronomical Observatory* program by $6.2 million, which applies to the last spacecraft in the series. A total of $165,900,000 was recommended for physics and astronomy by the Senate committee.

A House cut of $1.5 million in the *Surveyor* rover program was upheld by the Senate. Total lunar and planetary funds thus amounted to $213,115,000.

Funds of $31.5 million for biosciences, $42.7 million for meteorological satellites, $2.8 million for communications satellites, and $28.7 million for applications and technology satellites were approved as requested by NASA and voted by the House.

Full NASA request of $63.6 million for launch vehicle development funds was granted by the Senate committee. Three million has been cut by the House. Launch vehicle procurement, however, received only $178.7 million from the Senate, but $179.5 million from the House.

- **Advanced Research and Technology**—NASA's requests for $35 million for space vehicle systems, $34 million for electronics systems, $14.9 million for human factors systems, and $22 million for basic research, $58 million for nuclear rockets, and $14.2 million for solar and chemical power, were granted as approved by the House.

Full funding also was voted for aeronautical research at $42.2 million and sustaining university program at $46 million.

The tracking and data acquisition request, which the House had cut by $3.9 million, was recommended by the Senate committee for funding in full—at $246.2 million.

In a cut which the House did not make, the Senate reduced the technology utilization request of $5 million by $250,000.

In construction-of-facilities funds, the Senate's key action was restoration of the $10 million which the House had cut from the funds for the Electronic Research Center. Amounts of $2.7 million for Ames Research Center, $2.4 million for Goddard, $8.25 million for Langley, $867,000 for Lewis, $2.3 million for Marshall, $284,750 for Michoud, $1.9 million for Mississippi Test Center, $1 million for Wallops, and $20.2 million for various locations, were approved.

However, the Senate cut $400,000 from the Kennedy Space Center and applied a small cut to the Manned Spacecraft Center construction funding.

Total construction funding approved by the Senate was $67,376,350, which was $7 million more than is in the House bill.

Administrative operations were approved at $596,100,000, $10 million more than the House voted but $13 million less than NASA requested.

After Senate action upon the Space Committee's recommendations, the Senate and House versions must be resolved in conference. ■

SNAP 50 Program Request Reduced $10M

The Joint Committee on Atomic Energy has cut the SNAP 50 reactor program request by $10 million.

Total request by the AEC, for authorization for SNAP 50 was $22 million. The program has been cut back in previous years by the Administration from a flight program, to a systems test, to component development.

During hearings earlier this year, members of the committee expressed the fear that the program like most other SNAP series programs, was going to be dropped by the Administration for "lack of requirement" after millions of dollars had been expended. They indicated that they felt that it would be better to cut back now.

No funds were cut by the committee in the other SNAP programs, or Rover nuclear rocket program. Total AEC bill voted by the JCAE was $2,550,521,000.

New Rockets Unveiled in Moscow

INITIAL ANALYSES by U.S. industry and government experts of photos of Russian rockets exhibited during the VE-Day parade in Moscow indicate the Soviets may have a solid-fueled ICBM in the *Improved Minuteman* class.

Interpretations of photos of the three-stage missile (top right and middle right p. 17) tentatively pin the booster diameter to 120 in. U.S. experts think the missile can deliver some 6,000 lbs. of payload over a 5,500-mi. trajectory.

The larger three-stage vehicle (above and top and middle left, p. 17), described by Tass as "similar" to those used to orbit cosmonauts, is believed capable of a manned mission. But U.S. spokesmen say the vehicle does not check out with previous reports.

The 120-ft. "Brezhnev Blockbuster" is solid-propelled, according to Russian press reports, but there is some doubt as to this in U.S. circles. One official told M/R that if the larger ICBM was involved in the manned launches and is solid-propelled, "we have been in error for some time in our knowledge of Soviet launch vehicles."

ABOVE: In first public showing, 120-ft.-long ICBM nicknamed "Brezhnev Blockbuster" by Western observers is drawn through Red Square during May 9 parade. Russian spokesmen said vehicle, believed to have thrust of more than 1 million lbs., is all solid-fueled and of same type used to orbit Vostoks and Voskhods. TOP LEFT AND MIDDLE LEFT, P. 17: Closer views from different angles of the huge rocket clearly show metal struts joining three stages. TOP RIGHT, P. 17: New three-stage, 100-ft.-long ICBM passes in parade. Broadcast during showing said missile carries nuclear warhead, uses solid fuel and can be launched from underground as well as from surface. MIDDLE RIGHT, P. 17: Another view of same weapon, called "Little Sister" by Russians, and believed by Western observers to be counterpart of U.S. Minuteman—perhaps in advanced version. BOTTOM, P. 17: Mounted in sheath and carried aboard tracked vehicle that reportedly also serves as launching platform, 40-ft.-long solid-fueled medium-range missile moves through parade route. Missile, not previously displayed, was dubbed "Iron Maiden" by observers.

Eurospace Clings to Transporter Idea

Despite U.S. criticism, many members feel aerospace ship offers best chance to make separate European contribution and promote industry

LOS ANGELES—Cold water thrown on the *Aerospace Transporter* concept by Americans during the Eurospace group's tour of the U.S. has not dampened the enthusiasm of many of its supporters.

Their defense of the concept against technical and economic arguments makes it clear that it holds appeal not merely because it is spectacular but also because it symbolizes vital reasons why the European industry feels it must have an imaginative and challenging space program.

Whatever may be chosen as an ultimate, long-term space program, the Eurospace group feels there are a number of important considerations it must encompass to meet European needs:

—Europe must keep abreast of advancing technology in order to maintain a healthy industry and economy and contribute to free world security. To do this, a European space project is essential.

—A project or projects that would support the European aircraft industry by utilizing its talents and personnel to the fullest possible extent is desirable.

—A project such as *Aerospace Transporter*, which would advance aviation as well as space technology, is the best way of providing support for the aircraft industry in Europe.

—The project should have long-term aims in space that will be of general value to space operations rather than be restricted to specific areas such as weather prediction or communications.

—It should not duplicate U.S. or Soviet projects.

The Eurospace delegates wound up their tour May 7 on the West Coast.

● **New organizations**—The Europeans recognize that to make a space program work, the essential ingredients are worthwhile long-term objectives, a capable management and a good grasp of technology.

In general, they feel that they have the necessary technology. Hence, they are concentrating on studies of objectives, of which the *Aerospace Transporter* is currently drawing most attention, and development of European managerial resources within organizations such as ELDO (European Launcher Development Organization) and ESRO (European Space Research Organization).

A third organization of this type, for satellite communications, is likely to emerge within two years; a weather satellite organization will follow.

Specialist organizations of this type are seen as essential precursors to establishment of a European agency comparable to NASA.

● **Keeping up**—The basic importance of a space program to Europe was emphasized by Herbert Schneider, director, Bundesverbandes Der Deutschen Luft- Und Raumfahrt-Industrie E.V. In his view, "we must do work in all space fields, not just in communications satellites or in scientific payloads for American rockets."

The underdeveloped countries in 10 to 20 years will be able to produce industrial products of the type the rest of the world does now, he said. "This means that the present free world must be able to build better products by that time. The most likely way to get new techniques, new methods of production, is from spin-off from space production, which will be very, very necessary for having an industry program and security in the future."

Schneider feels it is therefore in the common European interest that European industry develop the same skills America has out of its space effort.

"The modern techniques we saw in the U.S. were impressive—but only in the magnitude. We have the technological skills to do these things once our people decide to spend the money on them," Schneider said.

V. A. Altovsky, Compagnie Française Thomson-Houston, declared that Europe "must have its own technology, be able to do these things for itself." An *Aerospace Transporter* is attractive for both economic and social reasons, he said, adding it is felt such a project will "support the European aircraft industry."

In reply to the suggestion that perhaps one way of cooperating with the U.S. industry would be use of expensive American equipment such as simulators, Altovsky declared that Europe must build its own know-how, even to simulators.

"We must have our own so we will really know this technology," he said. "We feel this is essential if we are to really do something. We need to have the basic technology for space and we should develop basic European systems. We already have our own solutions in such fields as automobiles, aircraft and atomic energy. I am pretty sure that we will have a European space program that will be different from yours and will not follow your lines."

Europe is also anxious to do its own space work, rather than buy equipment or services from the U.S., to avoid balance of payment problems.

● **Third approach needed**—Altovsky added that he had seen a "tremendous duplication" of effort in the U.S., with 20 or 30 firms with space simulation facilities, as one example. "In the face of this, you cannot accuse us of duplicating American work if we choose to set up our own manufacturing facilities," he said.

C. R. Turner, Britain, Eurospace technical secretary, and Jurgen Lambrecht, Junkers, told M/R there is a very strong feeling among the Europeans that American and Russian approaches and solutions to space may be biased because they are in the context of a space race between the two big nations.

"Therefore, a third—European—approach is indicated, and this is where Europe may very well be able to make a most important contribution," said one. "We should not undertake a *Mercury* or *Apollo* program," said another spokesman. "This would not only be a waste of money but would not make a contribution in a new area."

The idea that the ultimate European space goal should not duplicate U.S. and Russian approaches is a good point in favor of an *Aerospace Transporter* effort, supporters pointed out.

Lambrecht, one of the most enthusiastic supporters of an *Aerospace Transporter* program as a long-term project, said he felt that it could be "an *X-15*-type program, using two or three craft," perhaps lifting bodies rather than a winged craft.

Lambrecht and other supporters believe the advantage of this approach is that "technology could be advanced step-by-step, from the ground up, nothing 'far-out', no immediate jump into space." ■

PARTNERS

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Army Prepares Sprint Pop-up Flight

Shot from White Sands, likely in fall, awaits completion of new silo; Nike-X priority reaffirmed in testimony; Zeus back on equal footing

by Donald L. Zylstra

THE THIRD FLIGHT TEST of the *Nike-X* program's *Sprint* missile will be the first to feature the pop-up firing in sequence with a regular test flight. Testing of the pop-up procedure coupled with a flight is contingent on the finishing of a new silo at White Sands Missile Range, N.M., to accommodate the *Sprint*. Completion of the pop-up silo facility, scheduled this summer, should permit the third flight to go from WSMR sometime this fall.

Two silos capable of supporting a *Sprint* launch over the missile's entire flight regime will be built—one at WSMR and one on Meck Island, 20 mi. north of Kwajalein Island in the Pacific Ocean. The Missile Site Radar (MSR) planned for installation in connection with Army's Kwajalein facility will also be built at Meck. It will be operated in conjunction with the more complex, higher-powered Multi-function Array Radar (MAR) to be built on Kwajalein. The site has been marked and prepared, and construction of the Kwajalein radar is scheduled to begin soon.

Army chiefs testifying before Congressional committees on *Nike-X* have uniformly stressed the "building blocks" aspect of the system. Regardless of whether the system uses *Zeus*, or the *Sprint* missile developed under the *Nike-X* concept—or both—the Army is doing everything possible to emphasize features which presumably will permit installation of only a few launch complexes and system components, or a great many, depending on the level of defense to be provided.

An urban defense system has been considered for the protection of various combinations of populated areas—at costs ranging from $6 billion to $8 billion to $20 billion. Totals of 13, 23 and 49 cities have been mentioned for possible inclusion in defensive deployment of the *Nike-X* anti-missile missile network.

• **Highest-priority R&D**—Whatever the considerations as to ultimate deployment, the Pentagon continues to make noises calculated to stress the importance it places on *Nike-X*. Dr. Harold Brown, Director of Defense Research and Engineering, told the House Armed Services Committee that the system has the highest priority of any R&D effort in the military establishment. By the end of Fiscal Year 1966, an estimated total of more than $2 billion will have been spent on the combined *Nike-X/Zeus* effort.

Requests for FY 1966 total $390 million, plus $3.6 million for construction items. In FY 1965 the combined programs (*Nike-X* and *Zeus*) were funded for a total of $347 million. FY '65 will end with an estimated total of $243 million in unobligated balances in the program, with FY '66 unobligated balances expected to reach $252 million.

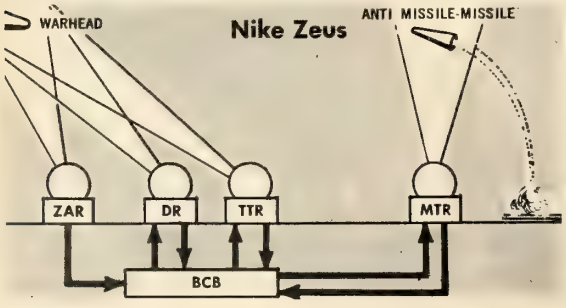
The Senate Committee on Armed Services questioned Army Chief of Staff Gen. Harold K. Johnson closely about a proposed $200 million for *Nike-X* pre-production engineering which was trimmed from the FY 1966 Army budget by the Dept. of Defense. Senator Strom Thurmond (R-S.C.) asked Johnson if this sum spent for pre-production engineering would "in any way constrict the options on possible configurations for ultimate deployment of *Nike-X*." "To the best of my knowledge, no, sir," Johnson replied.

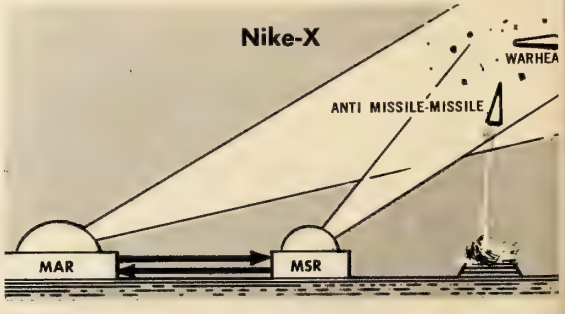
• **Comeback for Zeus**—Research and development connected with the *Nike-X* program has evolved some dramatic understanding of *Zeus* in its exo-atmospheric role and effectively read it firmly back into the *Nike-X* system. Today *Zeus* is a co-equal and essential partner with *Sprint* in the system, and the system's developers are taking steps to optimize its operational capability in the "barrage" role above the sensible atmosphere.

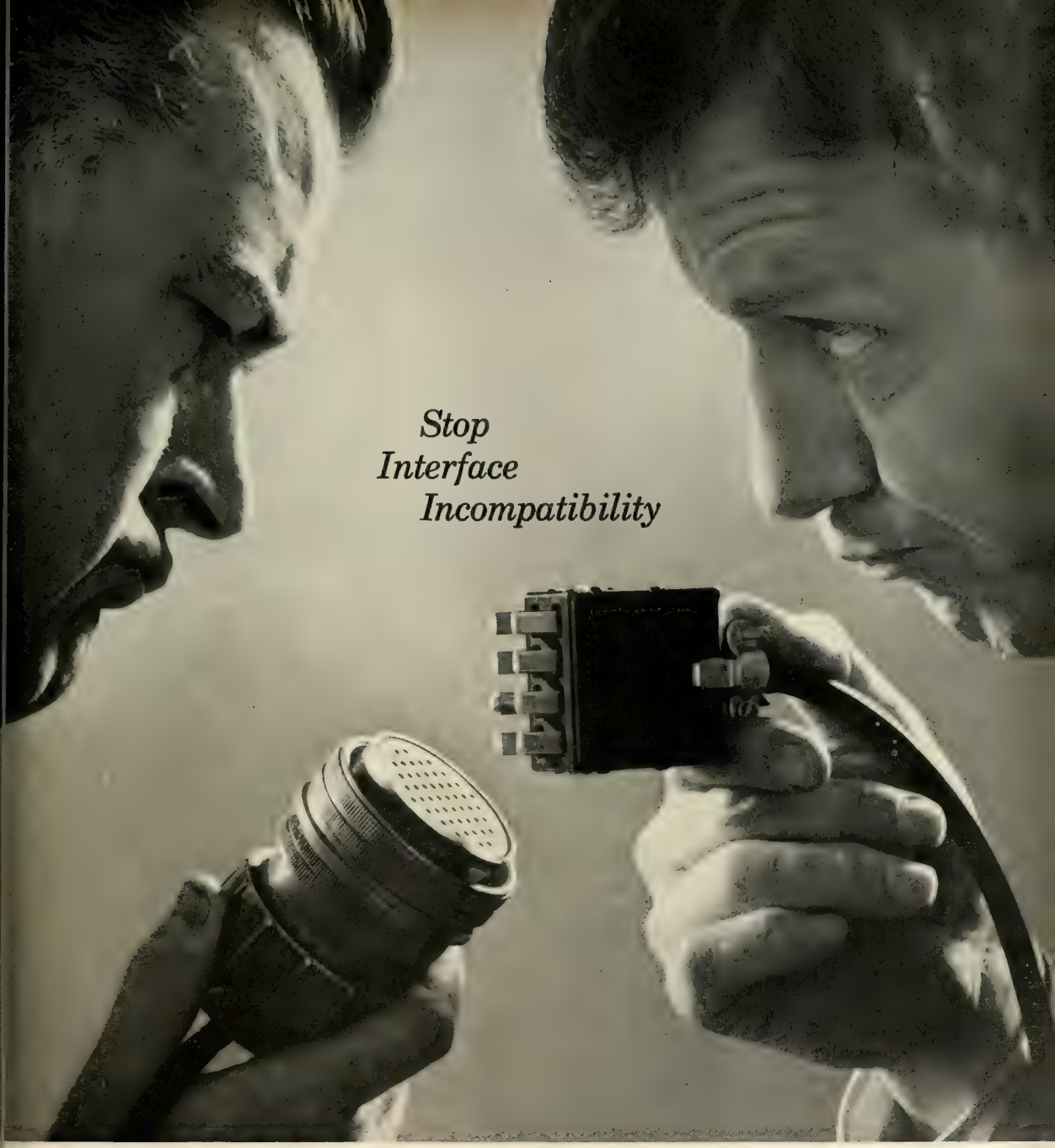
Only two of the original *Nike-Zeus* radars—the two acquisition radars, one at Kwajalein and one at WSMR—have been completely deactivated. The others continue to perform valuable functions in gathering data for the development of the *Nike-X* system and as components of the National Range complex. Two *Zeus* radars remain in service at WSMR—a discrimination radar and a target track radar. Two target track radars and two missile track radars remain in operation at Kwajalein.

The *Nike-X* MAR can take over all four functions of the *Zeus* radars—acquisition, discrimination, target tracking and missile tracking. Presently, MAR functions are confined to the first three. The MSR is a phased-array device like MAR, but lower powered and with shorter range. It is capable of directing a score or more *Sprint* or *Zeus* missiles to their targets simultaneously and can take over other functions such as target tracking and limited acquisition. ■

SCHEMATIC COMPARISON shows how four radars in early Zeus system have been replaced by only two in new phased-array equipment designed for Nike-X. MAR replaces ZAR, TTR and DR. Underground MAR building is counterpart of Zeus Battery Control Building. MSR serves the same guidance function as MTR.







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DOUGLAS

MISSILE AND SPACE SYSTEMS DIVISION

Technical Countdown

ELECTRONICS

Low-Cost Video Recording Revealed

Audio-video recording on long-play discs could provide a new low-cost method for industrial and commercial training programs. Developed by Westinghouse Electric Corp., the system, called Phonovid, can provide up to 400 separate pictures and 40 min. of total playback from a 12-in., 33⅓ rpm record. Individual pictures are presented every 6 sec., during which time the next picture is built up electronically. Pictures can be held for longer periods by simply lifting the tone arm. Both sound and pictures are compatible with conventional audio/TV equipment and outputs, says Westinghouse, and are of broadcast quality.

Eclipse To Aid Ionospheric Study

During the May 30 solar eclipse, the rate of electron loss in the D-region (70-100 km) of the ionosphere will be studied by Cornell Aeronautical Laboratory using radar techniques. The eclipse, says CAL, provides a unique opportunity to study the predicted resulting rapid rate of change in electron concentration. Sponsored by the Defense Atomic Support Agency under a $99,000 contract, the measurements will be made using a 200-kw peak-pulse transmitter, a partial reflection technique and two ground antenna arrays. The latter are now being readied on Aitutaki Atoll in the Cook Islands. The D-region, least understood of all the ionospheric layers about the Earth, is believed to be the source of many ground communications problems.

Ionospheric Ducting Employed Successfully

Orbital spacecraft can transmit beyond the Earth's horizon by employing an RF ducting effect occurring between ionospheric layers, according to the Air Force Office of Aerospace Research. Recently proved with an Air Force satellite, OAR claims, communications can be maintained up to 12,000 surface miles, or half way around the Earth. The effort will be continued, reportedly, in an attempt to transmit even further with improved predictability and performance.

PROPULSION

Aeronutronic Demonstrates Restartable Solid

Using a variable nozzle throat area technique, engineers at Philco Corp.'s Aeronutronic Div. can start, stop, restart and vary the thrust of a solid rocket over a 3 to 1 ratio. Donald A. Carrison says that one test motor went through seven stop/start cycles at varying thrust levels without any component modification. The variable throat technique is called the L-Star extinction method. It cuts off burning by reducing the pressure in the combustion chamber. Ignition is achieved through injecting minute quantities of hypergolic gas. This approach avoids over-pressurization or excessive ignition delay. The motor grain was obtained from Jet Propulsion Laboratory, partner in the joint program with Aeronutronic. The test motor was a conventional aluminized solid unit.

ADVANCED MATERIALS

Be-Cu Alloy Cuts Machining Costs

A free-machining beryllium/copper alloy with the same mechanical and physical properties as conventional Alloy 25 is being marketed in mill stock by The Beryllium Corp. Field tests have shown that the alloy, Berylco 33-25, can be machined with the same tooling and at the same feeds and speeds as free-machining brass. Five beryllium/copper parts can be machined in the time previously required for two. The principal immediate application will be in connectors and other small electrical and electronic parts.

SPACE MEDICINE

Rare or Well Done?

The University of California has developed a technique for exposing primates to whole-body doses of protons. The primates are given uniform exposures of high-energy protons after being placed in a rotating mechanism located in the proton path. The work, done at Berkeley, is supported by NASA in an effort to establish baseline information. Work is now concentrating on the effects of sub-lethal doses accumulated during prolonged exposures.

Biomed Data Stored for Computer Use

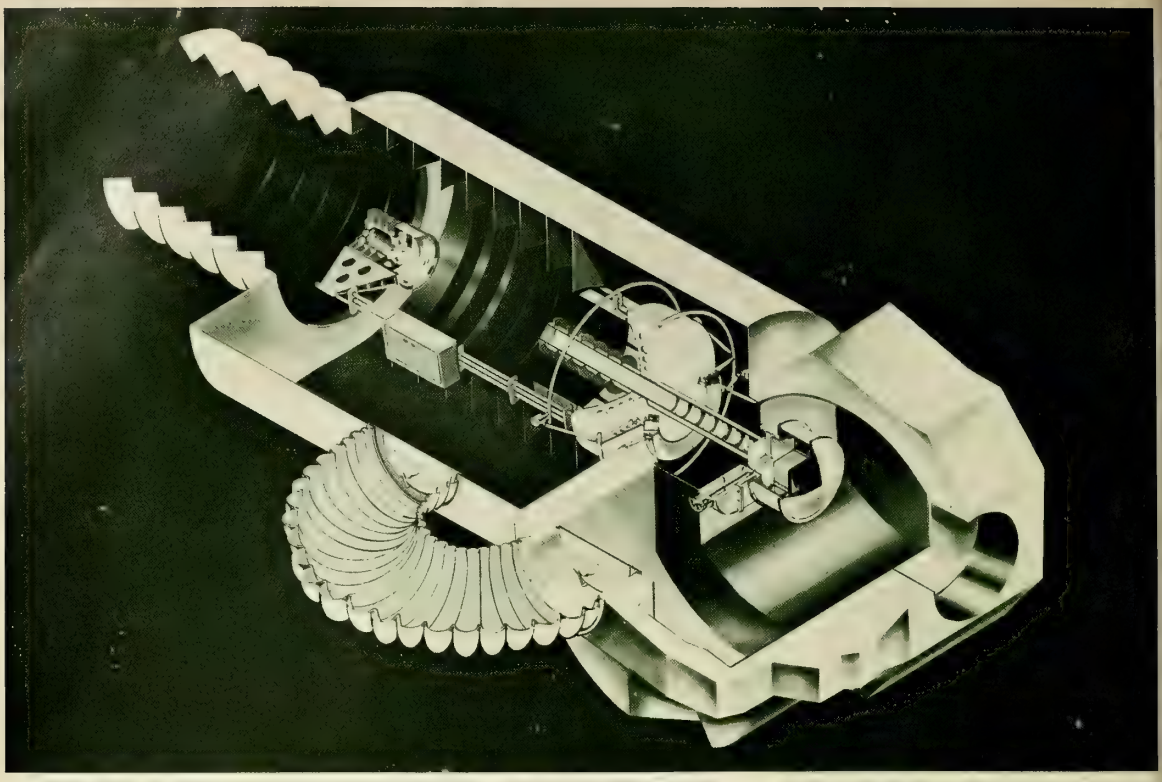
NASA has undertaken a program to computerize all flight and ground-based data on space medicine, including such data as those obtained from simulated space missions, special medical studies, and pre- and post-mission astronaut physical examinations. These data will then be available for real-time application during space missions, or "on call" for computer utilization.

Psycho-Physiological Tests Standardized

A standardized set of crew performance tests for ground-based studies and for actual spaceflight comparisons has been developed at NASA's Ames Research Center. The 25 tests are packaged in a console measuring about 3½ cu. ft., and weighing about 90 lbs. Classes of tests include thinking, motor skills, sensory functioning, group interaction and decision-making. More than one member of the crew may be tested at one time for crew performance tests.

New O_2 Source Studied for Space Cabins

General Dynamics/Electric Boat Division has found that alkali metal ozonides have potential in non-regenerative air revitalization systems for use in space ferry vehicles, military reconnaissance vehicles, near-Earth orbital missions and the like. In the first government-sponsored research in this field, G/D concludes that the compounds, such as potassium ozonide, can be safely handled. The fact that the material gradually decomposes at cabin temperatures to yield breathing oxygen, G/D said, offers possibility of engineering innovations in use of these materials not possible with oxygen source compounds.



ARTIST CONCEPTION shows configuration of 40-in. aperture parabola attached to LEM ascent stage.

space systems

Plans Told for Manned Observatories

Two years of work at Chrysler assumes use of Apollo hardware; advantages of man in the system seen as outweighing liabilities

by William S. Beller

NEW ORLEANS—A manned, Earth-orbiting astronomical observatory, based on *Apollo* hardware, will probably be part of the United States space effort of 1968-1972.

This assumption underlies nearly two years of continuing work by the Space Div. of Chrysler Corp. aimed at determining the missions and instruments that would be needed.

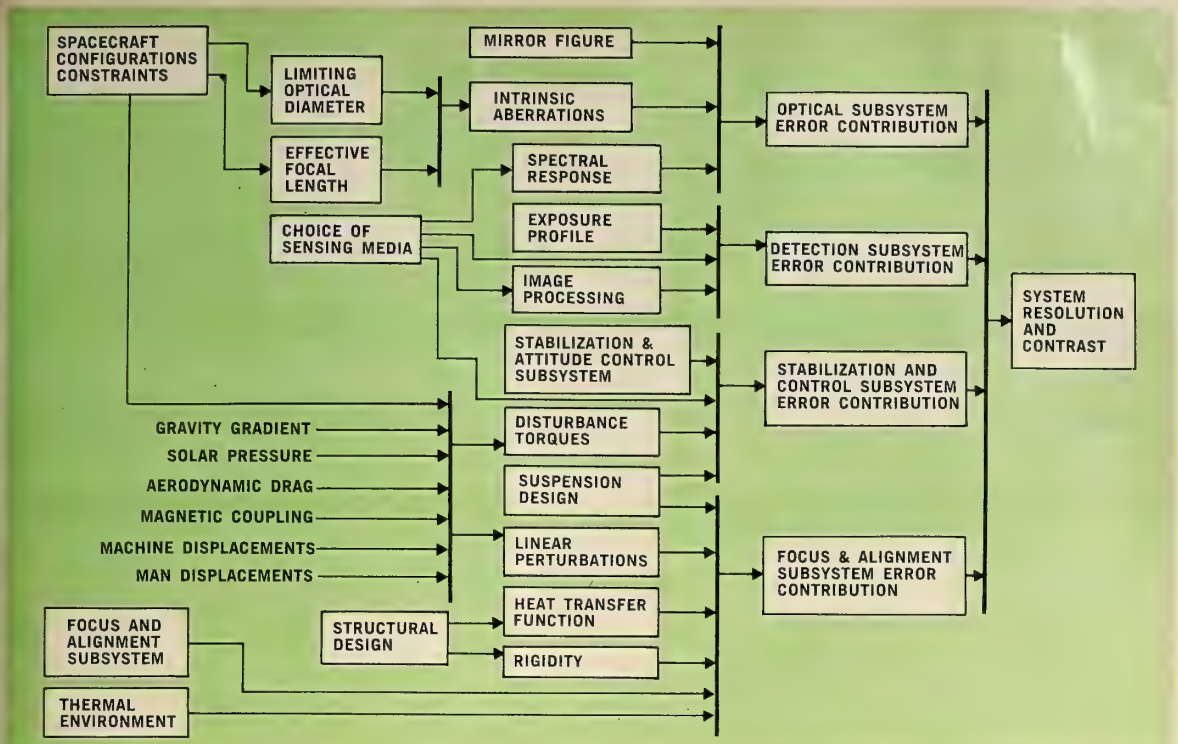
In light of current NASA studies, the company's assumption appears to be a good one. "Our planning (in astronomy) involves modest extensions of *Apollo*-type hardware with man in it," a highly-placed NASA official confirmed to MISSILES AND ROCKETS (see p. 30). He would not commit himself further pending completion of the studies sometime this summer.

Through its advanced work, involving a staff of scientists working full time and some hardware development, Chrysler hopes to be well ahead of its competitors when proposal time comes around. Chrysler officials indicate that the company's current emphasis on space astronomy stems from a strong feeling that the next generation of space missions will have to include orbiting telescopes of substantial size.

They would be used for systematic observations that the *Orbiting Astronomical Observatory (OAO)*, because it is a first effort in space astronomy, is not equipped or sophisticated enough to do. From these observations, scientists could expect to get deeper insights into the laws of nature, leading to a fuller understanding of the world and universe—a major spur for Congress and the citizens for funding space exploration.

● **Apollo extensions**—In an analysis of space missions and spacecraft for them, two approaches can be taken: the missions can be tailored to the spacecraft, such as *Apollo*, or the spacecraft can be designed for the missions. Chrysler took the first and then cautiously moved toward the second by modifying *Apollo*.

At the same time, the company looked into using a Lunar Excursion



System resolution parameters for Chrysler's manned Earth-orbiting observatory.

Module (LEM) bus to carry to the Moon's surface an optical telescope with an extremely long focal length—7,200 in. Astronauts would set up the experiment, which would then be run by remote control from Earth.

Based on early North American Studies of *Apollo* extensions, Chrysler related its work to 90-day Earth-orbiting missions. NASA, meanwhile, said it was considering 30 to 45-day dwell times in Earth orbit and also use of a gutted LEM for Earth-orbital missions. Chrysler, accordingly, used these new variables in its designs, and also the possibility that the entire LEM adapter volume might be used as a laboratory module.

Because of the limitations of Earth-bound observations, space telescopes could bring as much change to astronomy as the telescope itself did in the hands of Galileo. Sixty to ninety per cent of all material in the universe is hydrogen gas. The hydrogen atom radiates in many wavelengths, the strongest in the Lyman alpha-line. But the Earth's atmosphere can not pass the Lyman alpha-line because it is too far into the ultraviolet. This is one window among many that would be open for a space astronomer.

There are other detriments to Earth viewing that would not exist in space:

—City lights and a phosphorescing sky, which dim the appearance of heavenly bodies.

—Boiling of the atmosphere, as when heated air rises from a hot road making observed objects appear wavy.

—The best an observer on Earth can do is to magnify a body by 1,000 diameters. Louis Epstein, a Chrysler astronomer, said this degree of magnification can be used so rarely, however, that astronomers might hark back to it in conversation with, "Do you remember that night back last October when . . . ?"

—the atmosphere absorbs practically all of the ultraviolet and infrared. Even balloon-borne instruments do not get a clear view of infrared, only bands within it. This leaves some phenomena impossible to see from Earth: young stars (protostars), for instance, do not shine hot enough in visible light to be seen on Earth—only in the infrared.

—Because of the boiling of the atmosphere, the center of globular clusters cannot be resolved.

In other terms, an Earth-bound detector has a bandpass of about 2.8:1. In space, this could easily be brought up to 10:1, using present detectors, according to Epstein.

● **Observing from space**—With the limitations of Earthbound observatories in mind, M. L. Scott, responsible on this Chrysler project for systems integration, pointed out the work the space telescopes could do in Earth orbit:

—*Wide-angle mapping of the celestial sphere*—This would also be done in UV and IR. On Earth, the Schmidt camera is widely used for visible-light mapping work. Chrysler has designed an off-axis Schmidt camera that puts the film magazine within easy reach of the operator—unlike the classical Schmidt where the film is inside the telescope. For an alternate scheme, Chrysler is investigating an all-reflecting Schmidt. Because it has no lens, the telescope is more useful in the UV.

—*High-resolution telescopy*—For this, a large-aperture, highly stabilized instrument would be used. The control system, suspension system, and telescope focus and alignment involve problems on which more work is needed, particularly when man is present.

—*Photometry and spectroscopy*—For these studies, Chrysler has designed some specialized telescopes that can be folded into an LEM adapter stage.

—*Radio astronomy*—Chrysler has completed tradeoff studies for radio telescopes and is getting into configuration work now.

● **Getting the narrow picture**—Big telescopes are used mostly for spectroscopy. The reason is easy to see: spectrograms can give information about the temperature, pressure, ionization,

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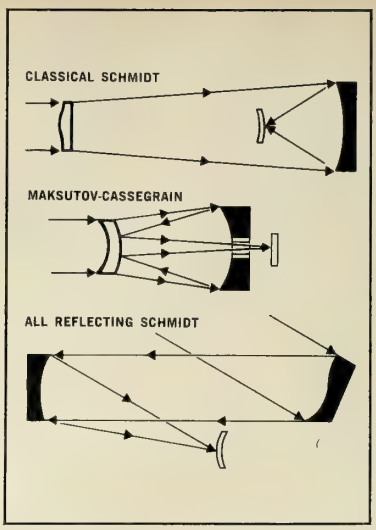

TYPICAL wide-angle telescopes.

material composition, magnetic fields and motions of a body.

Little time is spent using these telescopes on direct photography—that is, on wide-angle work. Yet the results of direct photography are of interest to all astronomers. It would show nebulae, clusters and the like that specialists could then examine in greater detail with single-purpose instruments.

Epstein says that both types of observations could be done from suitable orbiting telescopes, but that the program of work as well as the instruments would have to be different, just as they are on Earth.

Wide-angle work could be laid out well in advance; therefore, it could be automated. In spectroscopy, the work is exploratory and the data received influence the data to be sought and therefore cannot be laid out far in advance. An astronomer or technician has to be present to analyze the data and change the experimental apparatus. In a conventional observatory, spectroscopy is usually planned no more than two weeks ahead of time.

● **Man to help**—Chrysler assumes that man will be present to assemble telescopes in space. This has the advantage of eliminating 1) shock mountings around delicate optical elements, and 2) heavy structures to maintain alignment and focus during launch and injection into orbit. Even beyond this, however, the great merit of man is seen in his ability to maintain and service the equipment.

Other advantages include:

—An astronomer-astronaut would be invaluable to verify exposure, focus and other details of photographs taken from the space observatory. For high-resolution work, the photographic emulsion is better than the photo-electric cathodes.

—Telescope subsystem design is simplified when man is around, even if he simply slews the telescope from one part of the sky to another. While a star-tracker system could be used, it gets

Plans for Apollo Extensions

NASA expects to formulate its research plans for *Apollo* extensions by this summer for discussions within government and, in a general way, with industry.

Present thinking calls for small modifications of *Apollo*-type hardware with man in it to run or monitor suitable packets of proposed experiments in the 1968-72 time period. "Undoubtedly, one of these packets will be astronomy," M. J. Raffensperger, director of manned Earth-orbital studies, told MISSILES AND ROCKETS. He stressed, though, that "no conclusion has yet been reached about what a specific payload should contain nor what the gamut of packets should be."

Raffensperger said NASA would undoubtedly try to capitalize on the results of the *Orbiting Astronomical Observatory*, scheduled to make its first three flights late this year, for help in making decisions for *Apollo* extensions in astronomy.

When man is added through an *Apollo* extension, the system's flexibility is increased enormously. NASA is trying to see how "we can capitalize on his imagination, scientific background and ingenuity to modify in-flight details of experiments based on what he's learned," said Raffensperger.

He also said that the LEM ascent stage looks like it would be a valuable container for the packets. "We could hook on external hardware in the LEM adapter, if necessary," he said.

Observing that *Apollo* extensions could orbit 45 days, Raffensperger said it would be good if the stay could be extended as long as 90 days. The life support system determines the dwell period and the amount of electric power that might be needed to run the experiments.

Raffensperger said that *Apollo* extension sensors would look Earthward as well as skyward for scientific information.

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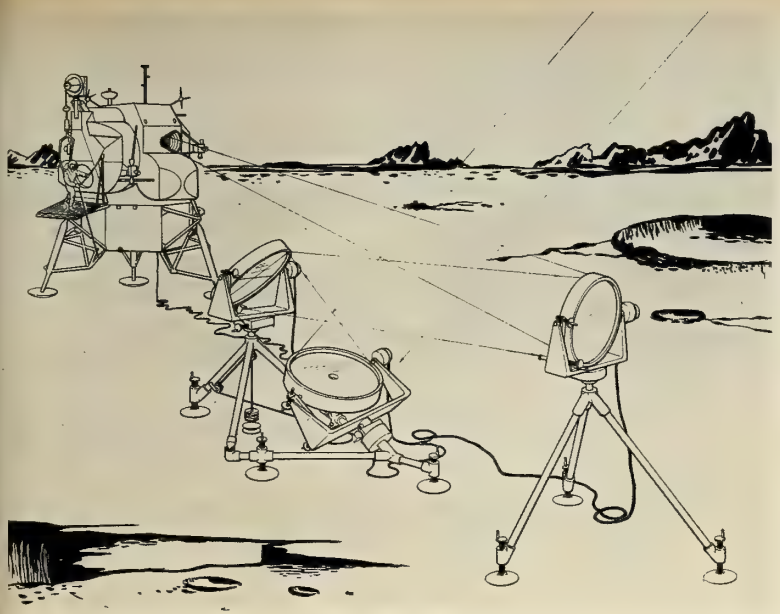

AN EARLY-GENERATION lunar-based telescope. Figure shows a coelostat-type telescope, which could be set up by man and operated remotely. Such telescopes can exhibit extremely long focal lengths.

complicated, especially when the gimballing angles of the star trackers are exceeded, when one of the stars becomes occluded, or when a lock is made on the wrong star.

—Man in space can also make one instrument do the work of several. One example is the Schmidt-Cassegrain telescope that Chrysler developed for space work modeled after an East German telescope in Jena. By suitably cutting in or taking out small components, the astronaut can have a Schmidt (or wide-angle) camera, a narrow-field Cassegrain, or a spectroscopic telescope.

The use of man is not without its problems. When in orbit with the telescope, his disturbance torque is about three orders of magnitude greater than torques brought in by such other disturbances as gravity gradient or aerodynamic drag. At 200-n.mi. altitude, for example, an observer on a LEM adapter module with telescope might create a distrubing torque of as much as 10 ft.-lbs. In contrast, the disturbing torque caused by the Sun is only 5 x 10^{-5} ft.-lbs.

The rate of change of torque caused by man's presence brings up additional problems as does life support.

● **Redeeming factors**—There are several ways man's problems can be down-played and his assets emphasized. For example, control systems can be relaxed because some telescopic work does not need accurate pointing. In spectroscopy, either a star is, or is not, on the slit; the job may take longer to do if the star wanders, but there can still be high-dispersion spectroscopy work. For this purpose, Chrysler has designed a spectrograph that uses a 65-in. parabolic mirror for light-gathering; the system fits in the LEM adapter stage for monitoring by a man.

Other work that can be done with relaxed attitude control includes measuring the brightness of stars through photoelectric photometry. When a target falls on the photo cathode, instantaneous data are gathered; when it does not, a non-critical interruption in the data accumulation occurs.

The telescopes can be deployed attached to the LEM adapter module, coorbiting with the module or loosely coupled with it.

The loose coupling isolates the telescope from man, but at the same time, gives him visiting rights when needed. One approach Chrysler suggests is to suspend the telescope in three mutually perpendicular diamagnetic bearings. In this way, the instrument would be gimballed in the manner of a gyro. There would be no mechanical stricture; the high-frequency disturbing torques caused by man would not be carried over and there would be no thermal conduction path from the manned module to the telescope.

● **Problems with telescopes**—A refracting telescope or lens passes IR and UV radiations poorly—particularly UV. What UV is passed is out of focus; the lens is not achromatic. A cure may be found in the use of mirrors as reflecting surfaces where UV and IR must be preserved.

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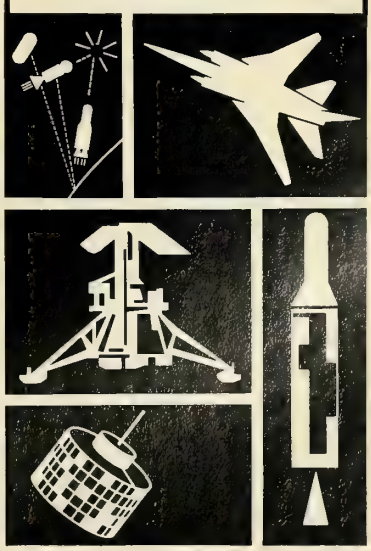

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Telescopes sag in a g-field. This was thought to be the sole restraining factor on the size of telescopes, and that it would be removed in the weightlessness of space. However, it now appears that the heat of the Sun may cause more of a problem from a structural point of view than the g-field. Several solutions to this problem of differential heating have been suggested.

Chrysler is considering both passive and active means. The most obvious passive means is to thermally isolate the telescope, but this is difficult to do. Some radiative or conduction energy is certain to pass.

Transverse thermal gradients may cause a telescope tube to bend. If a bimetallic tube is used, and the coefficient of expansion of the two metals appropriately chosen, the problem may be eliminated.

Thermal effects may also affect the length of the tube. Chrysler is looking into an old grandfather-clock principle to cure this ill. It calls upon the compound gridiron, which is simply three folded arms connected in series. Two of the arms have twice the coefficient of expansion of the third arm, and the result is several invariant lengths regardless of temperature changes. Chrysler has designed an orbiting Schmidt-Cassegrain telescope built on this principle. Studies are in progress to determine how this passive system may be supplemented by an active thermal control system for specific applications.

Optically, the best high-resolution telescope is the Gregorian with its two reflecting mirrors. Unfortunately, it is too long to put on the LEM adapter module. A shorter telescope with a flat secondary mirror could be used, but at the expense of resolution. Chrysler suggests that a good compromise telescope is the Cassegrain.

• **Mapping the sky**—The number of plates needed to map the celestial sphere is a function of the telescope's field of view. With a narrow field, a greater number of photographs are needed—so many, in fact, that if the field is very narrow, that the satellite time in orbit, which is also limited, may not permit the job to be finished. Therefore, it is important to get the widest practicable field of view.

One Mt. Palomar telescope, for instance, has a ½° field and would have to make about 10,000 photographs to map the celestial sphere. The 48-in. Schmidt at Mt. Palomar has about a 7-degree field of view and would need only about 800 photographs to do the same job.

A wide-angle camera, such as the classical Schmidt, uses a lens and a mirror for its elements, and beyond this it is long. The lens cuts down on the efficiency of the instrument in the UV,

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and its length makes the telescope difficult to put into a spacecraft.

The Maksutov-Cassegrain system is shorter but its very thick lens stops most of the UV.

The all-reflecting Schmidt, being developed by Chrysler, replaces the lens in the classical Schmidt with a sculptured mirror. It is a wide-angle instrument, usable in the UV, and can be put on a spacecraft such as the LEM module. Epstein believes that "it may be the camera to use to map the celestial sphere."

A coronograph usually has a small near-perfect lens as one of its elements. To capture UV, though, Chrysler has designed an all-reflecting coronograph and has folded it to put it on LEM.

● **Lunar astronomy**—The advantages of an Earth-orbiting astronomical observatory over an Earth-bound one may pale with respect to telescopy from the lunar surface. High-resoultion observations of heavenly bodies, for instance, may prove easier on the Moon because of the lunar inertia and a reduction of the thermal problems. On the Moon, where there are more than 14 days of daytime and an equal amount of nighttime, telescopes have time to reach thermal equilibrium, a contributing factor to high-resolution work.

Rocket shots from Earth up to altitudes of 900 n.mi. have shown intense Lyman alpha radiation in the UV region (1,216 Angstroms). Therefore, UV work may have to be done beyond the Van Allen Belt to get above the Lyman alpha skyglow. The lunar surface is suggested as the platform for this type of work.

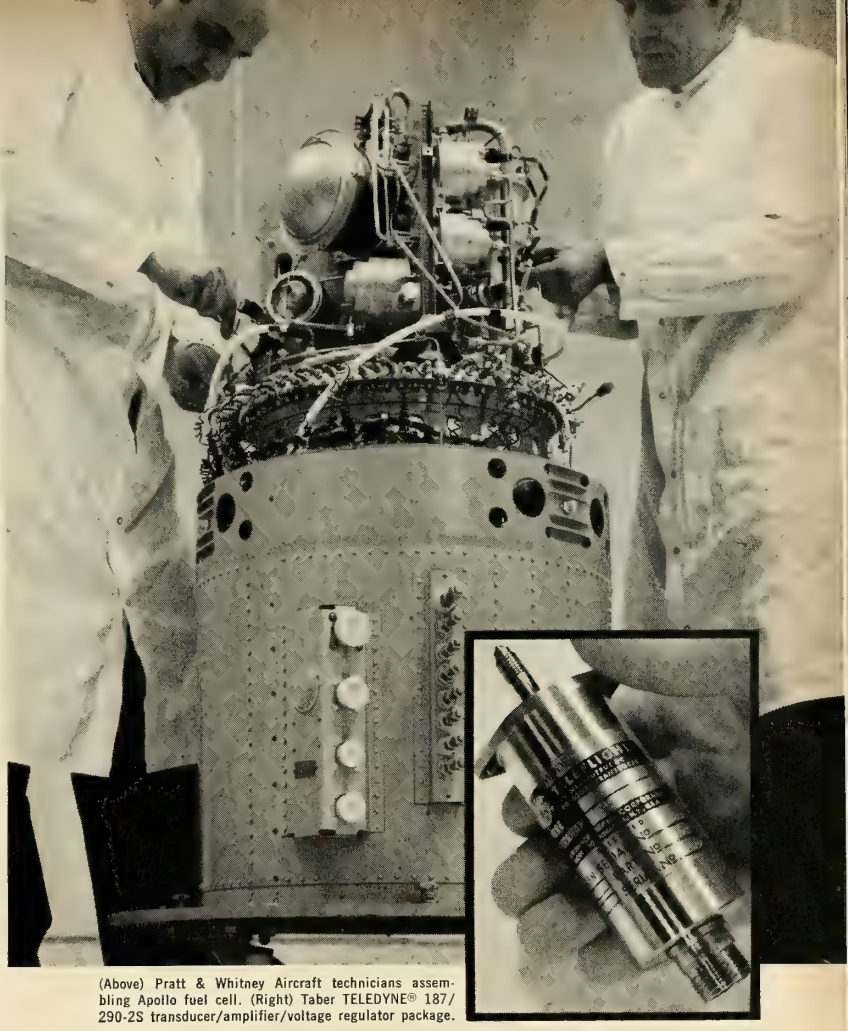
During the lunar night, the Moon itself baffles out the Sun, thereby getting rid of another impediment to detecting faint sources.

Other advantages of lunar telescopy include the ability to see interactions between the Sun and Earth. These could be related to meteorological phenomena on Earth.

Radio astronomy from the backside of the Moon would have the advantage of no Earth noise.

In the future, astronomers could do effective X-ray and gamma-ray astronomy by installing their instruments in a hole in the lunar surface, thereby getting directivity of the energetic primaries coming in from space.

Although advanced space telescopy in the U.S. will probably involve modifying *Apollo* hardware, the dividends from such research are expected to be high. From a cost-effectiveness point of view, if scientific knowledge can be considered as suitable payoffs, there is little doubt that manned orbiting and lunar observatories will have exceedingly high merit. ■



(Above) Pratt & Whitney Aircraft technicians assembling Apollo fuel cell. (Right) Taber TELEDYNE® 187/290-2S transducer/amplifier/voltage regulator package.

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Cubic Proposes Sharpening Targeting

HATS would use geodetic techniques, reconnaissance aircraft, relay planes and ground stations to supply missing link in location

by Rex Pay

SAN DIEGO, CALIF.—A targeting system for tactical missiles, artillery, or aircraft that gives an accuracy of 25 ft. at ranges up to 150 miles is being proposed by Cubic Corporation.

The High Accuracy Targeting Subsystem (HATS), as it is called, represents the application of geodetic techniques to reconnaissance systems. Cubic points out that implementations of these techniques are available and that they represent the missing link in current target location systems.

The proposal comes at a time when interest is increasing in target location for airborne support of ground troops. Most targets are located from the air. Also, enemy mobility is increasing, putting fresh demands on weapon-system response time and accuracy.

HATS would make use of a low-flying reconnaissance aircraft, two relay aircraft (which could be strike planes in a holding pattern), and two ground stations.

● **Old method not sufficient**—Conventional techniques for determining target location by correlating tactical photographs with a photomap are time-consuming and unreliable. An up-to-date photo map may not be available because, for instance, a monsoon may have changed the character of the terrain since the last map was made. Or the area may have no distinguishing features to which target location could be related, as in desert landscapes.

In a recent tactical exercise it was reported that about 50% of the photography could be correlated with positions by photo-map matching. The rest of the pictures were of good quality, but gave no indication of the location of the targets they showed.

Discussing alternative ways of measuring target location, Thomas B. Grady, Cubic Staff Engineer, claimed that tying in mapping sensors with aircraft navigation instruments does not give sufficient improvement in accuracy. He said Doppler position error can easily reach 300 ft. in fifty miles, unaided inertial systems can give a drift error of 2,000 ft., and Loran systems vary in their accuracy from 600 ft. to 6,000 ft., depending on ground conductivity conditions.

Inaccuracies of this size in target location are undesirable if the target is to be hit with the first strike. Cubic proposes that geodetic techniques should be used to provide the required ranging accuracy. Already these techniques have been applied to mapping missions. By use of a wide-band data link to transmit video, IR or radar data from the aircraft, an on-line targeting system could be developed.

● **How it's done**—The Cubic "Shiran" system developed for use in KC-135 photo mapping missions makes use of four ground transponders situated 150 miles apart to enable aircraft position to be located within 24 ft. This enables the rapid estimation of target location from aerial photographs, using ground equipment such as the Fairchild 406 Image Interpretation Cell.

The main problem with such systems lies in the need for the transponders in the remote aircraft to be in communication with the transponders on the baseline from which the range measurement is made. This is feasible if the reconnaissance aircraft is flying at a considerable altitude, but this is not possible in most tactical situations.

The penalty paid in using the UHF Distance Measuring Equipment is the requirement of a line of sight link between the low-flying reconnaissance aircraft and the DME equipment. If penetrations of 100 miles are to be made, accurate range measurements require putting a relay station up to an altitude of about 10,000 ft.

Typical configuration for the systems would be to put the relay and base stations about 50 miles behind the front line and to penetrate 100 miles with a reconnaissance aircraft flying below 500 ft. An additional 20 lbs. of equipment would be carried by the reconnaissance aircraft to give it a DME function that would enable its range to be located to within 25 ft.

Cubic developed a multi-sensor wide-band data link for the Air Force, which was exercised in the Goldfire I maneuver. The link transmits data from an aircraft flying low over enemy territory to a high-flying relay aircraft well back behind the battle lines. Although the use of relay aircraft was originally thought hazardous, it is now believed that if they are far enough back they can function unharmed. However, once such a relay capability is present, it can be used for tasks other than relaying sensor information. Most important, says Cubic, is the ability of such an aircraft to serve as a reference point for accurate targeting information. It provides, in fact, the capability of a high-accuracy over-the-horizon radar.

To develop a base line in the sky to give accurate range and bearing, two relay aircraft flying in widely separated holding patterns would be required. In turn, the locations of each of these aircraft would be accurately measured with respect to two well-separated fixed ground stations, referred to as the base and the master station.

● **Reconnaissance aircraft role**—The main requirement in the reconnaissance aircraft would be to tie in an inertial attitude sensor and a digital radar altimeter to the sensor equipment and to establish the nadir point in the pictures and the altitude from which they were taken. This information coupled with that picked up by optical, radar and infrared sensors would be transmitted over a wide-band data link to the relay aircraft and then down to the command post.

The relay aircraft could be tactical support aircraft flying in a holding formation prior to a strike mission, or they could be Air Force flying tactical command posts, the Marine Corps airborne UHF link, an unmanned drone, or tethered balloons. The additional equipment needed for them to carry out their relay function would weigh about 100 lbs., says Cubic.

A general-purpose computer would be needed in the main base unit to carry out the computation of range and

(*Continued on page 41*)

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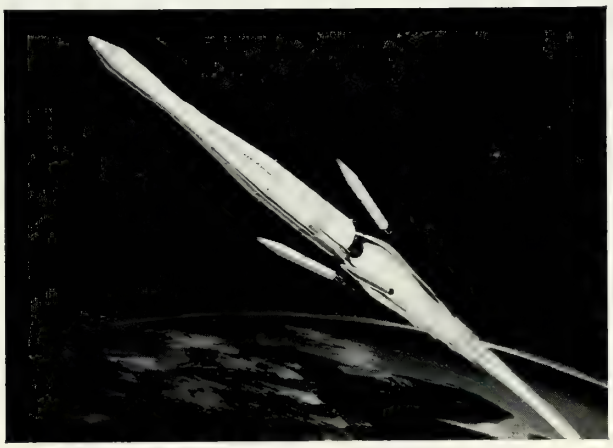

Biosatellite has quite a "crew" lined up for its several round-trips into space. And it's full of life.

Present orbital flights, planned for NASA, will operate from 3 to 30 days. The first will subject various biological specimens to radiation. Then rats, chiang liver cells and Arabidopsis go into space to test the effects of weightlessness on biological rhythm. Flights of 30 days duration will also orbit with an anthropoid (Macacus Nemestrina) and a complete life support system on board.

These living and scientific payloads are but a small part of the total technical content of the re-entry business. Programs for the development of the Mark 12 — Re-entry System for Minuteman II and a Maneuverable Ballistic Re-entry System are also underway. Development of maneuverable return-from-orbit systems will eventually lead to precision earth landings.

We also are working on the configuration and design of flight vehicles for entry into Mars' and Venus' atmospheres. Multi-place ferries and space station taxis are in our future.

The re-entry battle is just beginning, and now is an opportune time to join us. For further information about openings in SYSTEMS ANALYSIS ☐ SYSTEMS SIMULATION ☐ GUIDANCE & CONTROL ANALYSIS ☐ EXPERIMENTAL MEASUREMENTS ☐ MATERIALS DEVELOPMENT ☐ STRUCTURAL MECHANICS ☐ RADAR DISCRIMINATION ☐ PRODUCT SAFETY ☐ ELECTRO-CHEMISTRY ☐ NUCLEAR EFFECTS, write to Mr. Dan Nauer, Re-entry Systems Department, Section 394E-3, General Electric Company, 3198 Chestnut St., Philadelphia, Pa. An Equal Opportunity Employer.

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bearing of the target from the attitude and altitude information telemetered from the forward aircraft and from the relative ranges of the three aircraft. The AN YUK computer used in the Fairchild Image Interpretation Cell could carry out this task, but not at the same time as its image interpretation function.

An open or secure DME system can be used, says Cubic.

● **Offers one-shot capability**—The chief advantage gained is that this system gives the ground-based artillery or missilery a one-shot capability. That is, a telling blow can be struck the first time. Cubic points out that this can be achieved with a system made up of building blocks field-tested in other roles. Cost of equipment of this type may be expensive, but it appears to be the only way of giving the required accuracy and response time.

It assumes the presence of a wide-band data link for which there is an increasing demand, because it ensures that the information obtained by a reconnaissance aircraft is obtained, even if it is destroyed while returning to base. ■

Year's Test of SNAP 50 Type Bearing Completed

A MOLTEN LITHIUM lubricating bearing of the size required in the SNAP 50/SPUR nuclear powerplant has been successfully test-run for a year at Connecticut Advanced Nuclear Engineering Laboratory (CANEL), operated at Middletown, Conn., by Pratt & Whitney Aircraft division of United Aircraft Corp. for the Atomic Energy Commission.

The bearing test, part of CANEL's program to develop the compact nuclear-electric power unit for space missions, began May 1, 1964. The laboratory says a total of 8,760 hours has been accumulated, and several thousand additional hours of testing are planned.

Last fall, CANEL completed a successful 10,000-hr. (14-month) operation of an engineering-sized lithium-colombium alloy heat-transfer system, which was run at 2,000°F and a power level of 5,000 kilowatts. This, said P&W spokesmen, might be compared to running an automobile for 500,000 mi. entirely without maintenance.

In the bearing test, seven short stops and starts were made for maintenance of auxiliary test support equipment and to demonstrate restart capabilities for operational use.

IR Studies Show Moon Surface Makeup Varies

THE MINERALOGICAL composition differs from region to region over the visible surface of the Moon.

Infrared emission spectroscopy techniques developed by Air Force Scientists and used in lunar observations for more than a year at the Lowell Observatory, Flagstaff, Ariz., have resulted in the first significant data on the mineralogical composition of the Moon.

The studies were made by Dr. Graham R. Hunt and Dr. John W. Salisbury of the Air Force Cambridge Research Labs, Hanscom Field, and covered the spectral region of 8 to 24 microns.

Hunt and Salisbury conducted their investigation on 24 separate nights over the past year at the Lowell Observatory. The telescope time was provided by Dr. John Hall, director of the Lowell facility.

The Earth's atmosphere limited the data to the determination that compositional differences exist—not the exact nature of the materials involved. The detailed nature of the spectrum itself is disguised by absorption of the atmosphere.

● **Extra-atmosphere studies planned**—Since it is possible to learn the mineralogical composition by infrared spectroscopic techniques if the measurements are made above the atmosphere, AFCRL is planning a series of balloon-borne experiments designed to take such reading above 99% of the Earth's gaseous envelope.

The balloon measurement program—designated Project Skytop—should be underway with first flights within the next two months. There are plans for ground-based observations using the Lowell equipment during the balloon flights.

The experiment by Hunt and Salisbury provided the first data indicating mineralogical differences on the lunar surface. Observations were made with three different spectroscopes on different nights and with different telescopes—yet the results agreed. All instrumentation was laboratory calibrated.

The actual observations were made using a unique filtering arrangement developed by Hunt. The instruments were fitted with polished Olivinic and quartz reflectors allowing the investigators to search the lunar surface for differences in the "basic" and "acidic" regions of the spectrum.

Copernicus was chosen as the control and all other measurements were made in relation to this area. Copernicus reading established the base line for each series of observations with each instrument. "We made a loop—Copernicus, Northern Mare Imbrium, Tranquilitatis, Mare Serenitatis, Copernicus," says Salisbury.

● **Difference pinpointed**—One of the most significant findings revealed by the study is that Mare Cognitum, Mare Tranquilitatis and the floor of the crater Alphonsus have a similar composition—which differs entirely from that of Mare Serenitatis.

Since all of the *Ranger* photographs were of the areas of similar composition, the question arises as to the differences that might be found in an area like Mare Serenitatis.

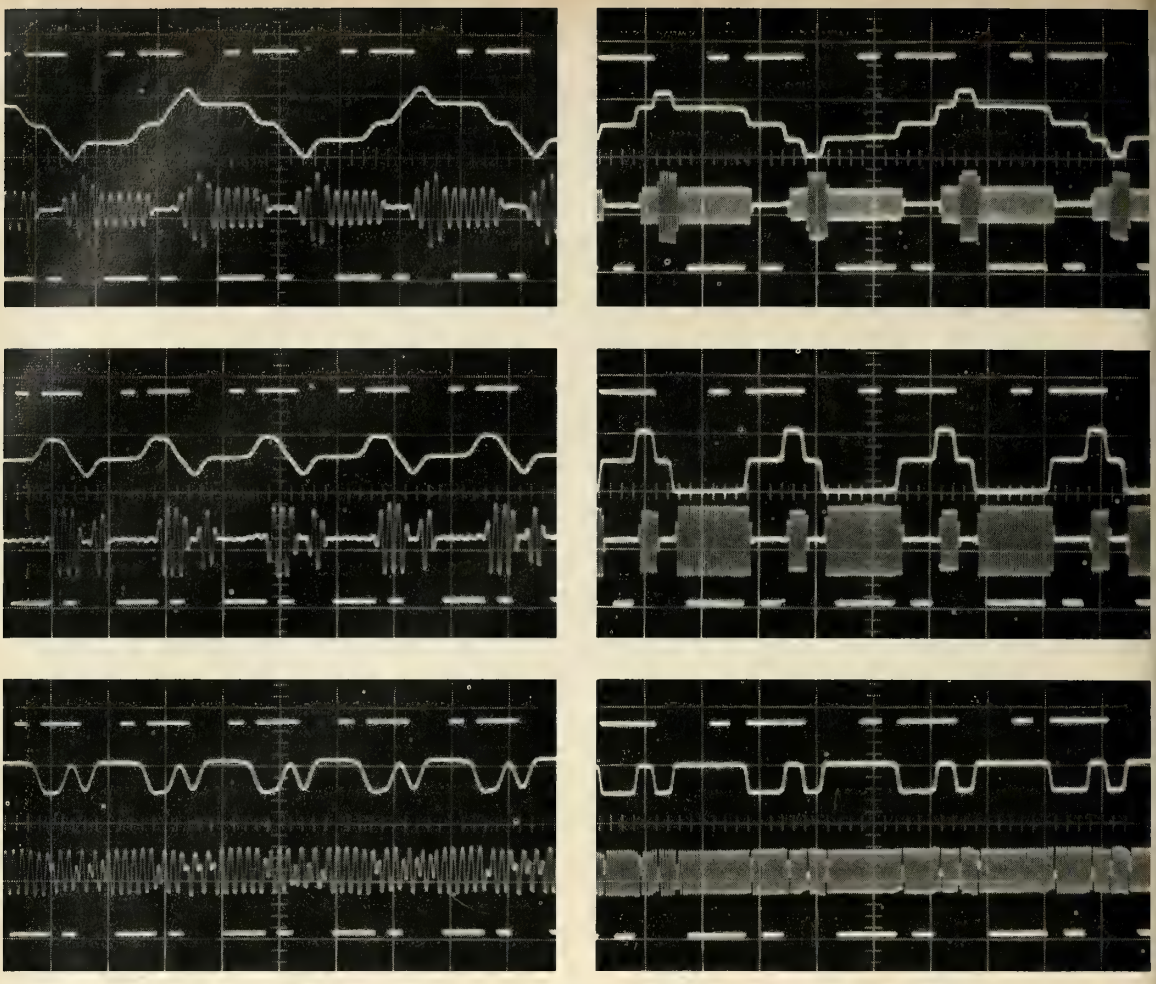
One possible explanation of the compositional differences could be that the surfaces photographed by *Rangers VII, VIII* and *IX* were all affected by secondary impacts of debris thrown out of large primary impact craters formed fortuitously in material of similar composition, while Serenitatis is unaffected in this manner.

Thus, say Hunt and Salisbury, it is possible that the frequency of small secondary quarters is much lower on Serenitatis. It also may be covered with material of a different composition.

Both Hunt and Salisbury feel the more likely explanation is that not all mare surfaces are composed simply of the same materials.

There are other possible conclusions. Infrared methods involve only two variables—the least of all indirect lunar investigative approaches. These are that differences in data can be caused by differences in composition or marked differences in grain size of the material studied. The apparent spectral differences might be the result of changes in grain sizes on the lunar surfaces studied.

In either case, the Air Force findings suggest that one of the more important areas for further study is Mare Serenitatis. ■



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Our space talk began at the dawn of the space age with the worldwide Minitrack network and grew up with the Mercury, Advent, Syncom, and Gemini systems. We are feeling the pulse of the future through studies on MORL, OSSS, ALSS, LORL, MOL, and Voyager.

In the hard world of space hardware, we are currently building equipment for a rocket program. We have recently developed an advanced 5-watt solid state S-band transmitter and a low noise receiver. We are in the process of developing a new generation of ultra-reliable wideband data link aerospace communications systems with a mean time between failure goal of 10 to 20 years.

In addition, we are developing an electronic camera with a sensitivity and response time markedly beyond the scope of present space sensors.

If what we've been talking about is in line with your next space project, contact us at Bendix Radio Division, Baltimore, Maryland 21204. Perhaps we can talk something up.

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Test Rig Simulates LEM Landings

Grumman facility will assist in determining how much astronaut protection must be provided in restraint system

BETHPAGE, N.Y.—Disagreement over how much safety restraint the astronauts will need as they lower the Lunar Excursion Module to the Moon has resulted in a unique testing program at Grumman Aircraft Engineering Corp.

The split in opinion occurred between physiologists—who felt that the pilots of the LEM should be protected against all possibilities of rough or bumpy impact—and the astronauts themselves, who were dismayed when confronted with what had been designed for them. The astronauts, wanting maximum freedom of movement, would rather rely on their own balance.

LEM crew systems people at Grumman are working on a compromise situation and are using a new test rig on which pressure-suited subjects are pounded about with the kinds of forces that presumably could occur if the LEM encounters trouble with lunar surface conditions as it touches down. As it now stands, Dr. Robert Del Vecchio told MISSILES AND ROCKETS, these safety devices will be provided:

—The astronauts, who will stand in the vehicle throughout the LEM mission, probably will have a waist strap similar in purpose to that of a window washer. Besides reducing lateral movement—which could cause damage to the suit backpack or to equipment the pack might come in contact with—the strap would enable the astronaut to lean back for the long periods he will have to look out of the port in the ceiling of the LEM. It has been decided that docking and rendezvous will be accomplished by visual sighting through this port.

—Force-absorbing arm rests will be provided for each astronaut. Each arm rest will move downward independently 3 in. under a force of 180 lbs., absorbing shock. The astronaut can then release the mechanism and the arm rest will return to the pre-impact condition. These would be stowable and used for impact only.

—Small handholds will enable the astronauts to brace against falling forward and into the windows or instrument panel. These are all that remain of an original concept in which a horizontal bar was placed across the instrument panel. It was discovered that this obscured part of the panel, and most of the bar was not used anyway.

—Velcro foot pads and possibly bars on the floor to secure the astronaut from falling and from bouncing upward at landing are now being tested.

● **Testing program**—Grumman began working on the problem of the restraint system some months ago using a vertical drop testing rig. It was decided that in large part—at least for straight vertical drops—the astronauts were right in rejecting the highly restrictive original concept. Impacts up to 8 g's, it was determined, can be sustained with little problem.

SUBJECT tries out restraint system in Grumman test rig for simulating biaxial loads LEM occupants may encounter.

The second test phase imposed horizontal forces. A 1,000-lb. hammer was rigged to hit the side of the mock capsule. The capsule could be rotated so that the impact would come on any side.

However, it became apparent that more realistic simulations were necessary. The jolts, if they occurred during landing, probably would be caused by the vehicle's coming down on an uneven surface and lurching to one side, or actually landing off-balance. Classic lateral or vertical impacts appear unlikely.

What the crew systems group dread more than possible injury—for the chances of that seem slim—is the possibility that the impact might send an astronaut into the window, or cause him to rip his pressure suit on an instrument switch or something else projecting into the cabin.

● **Multi-component forces**—A new test rig that can impose biaxial loads from almost any direction was designed. Compressed gas is used to create loads identical to those calculated as possible for LEM landing—to a maximum of 2.5 g's, lateral, and 4.5 g's, vertical, and almost any resultant of the two.

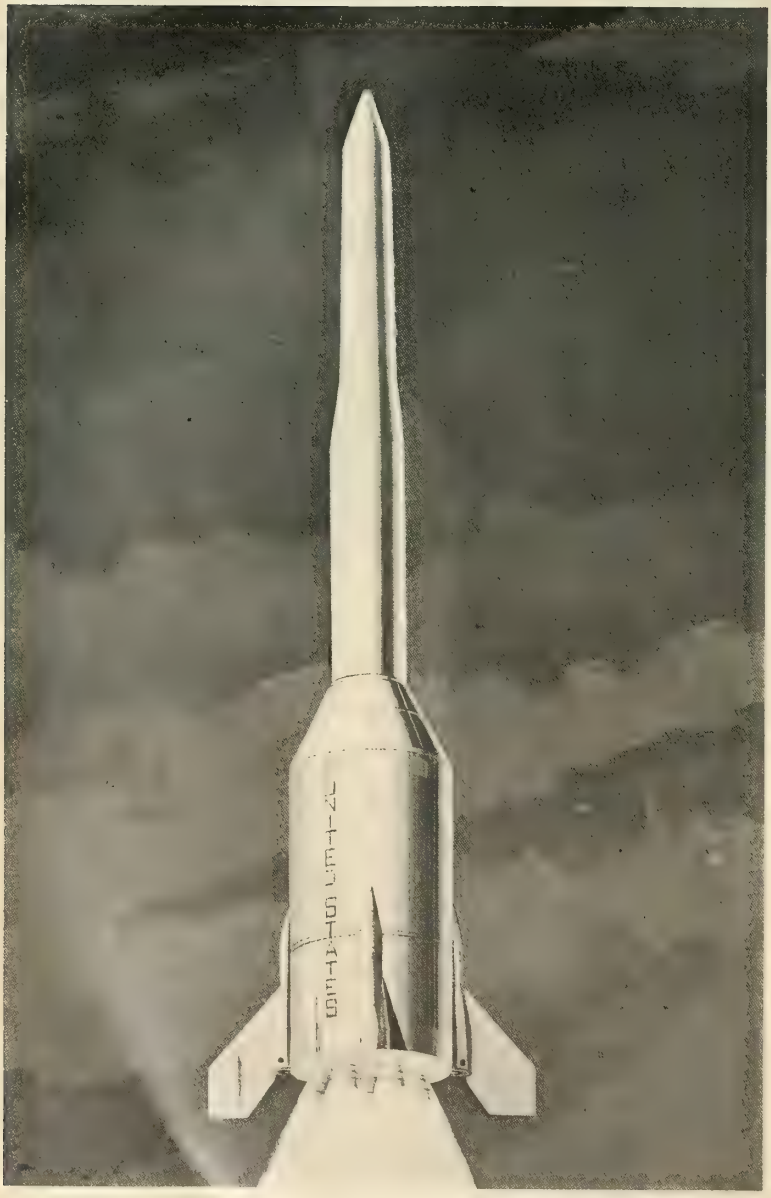
These were found to be well within human tolerance, but interaction between the pressure-suited astronaut and the equipment is now the main concern. The station is a rough representation of half of the LEM—one pilot's station—with frangible window. Panels, straps and other devices simulate the position of the instrument panel and the equipment to the side and rear of the astronaut.

The whole outfit is heavily instrumented, with sensors on the cage, and accelerometers installed on the test subject's chest, pressure suit and gloves. An anthropomorphic dummy is used to check out each test series. ■

Little Joe II Uprating Proposed

Wide variety of applications seen for booster, including use with Minuteman to produce first solid-propelled orbiter

by Willard E. Wilks



CONCEPT of Little Joe II-Minuteman combination that would produce vehicle capable of placing more than 2,000 lbs. into 100-mi. orbit.

SAN DIEGO, CALIF.—Mating an uprated *Little Joe II* booster with a *Minuteman* ICBM could produce the first solid-propellant orbiting vehicle—one capable of placing more than 2,000 lbs. into a 100-mi. orbit.

A plan for creating such an orbital *Minuteman* upper stage has been presented to NASA headquarters and the Langley Research Center by General Dynamics/Convair, prime contractor for *Little Joe II*.

The fact that both vehicles exist and possess the inherent reliability of solids might make the proposal attractive from an economy standpoint, since no development would be needed.

● **NASA Minuteman interest**—Replacement of 300 early *Minutemen* with *Minuteman II* has been under discussion for some time, and NASA has been investigating the possibility of using the phased-out ICBM's. This has sparked interest among companies in the big solids program as a possible way of finally initiating a program that will demonstrate the advantages of solids to the doubters.

The use of *Little Joe II* in combination with *Minuteman* is only one application General Dynamics has in mind for an uprated version of the booster.

The effort is aimed at a number of possibilities either proposed by industry or originated as possible requirements by NASA, Air Force and the Advanced Research Projects Agency. These include demonstration of the feasibility of recovering the *Saturn* S-IC stage with a parachute system, creation of a *"Super Scout"* using surplus Wing I *Minuteman* ICBM's and flight testing of various vehicles and their systems—including the Mars lander, *Voyager, Surveyor,* the *M-2* lifting body, the *Manned Orbiting Laboratory-Gemini* configuration, the *Apollo* Service Module, and a hypersonic ramjet. In addition, ARPA has studies on a re-entry payload launch vehicle (*RPLV*) and a larger-payload intermediate payload launch vehicle (*IPLV*).

At the moment, *Atlas* is the only booster that has been considered by

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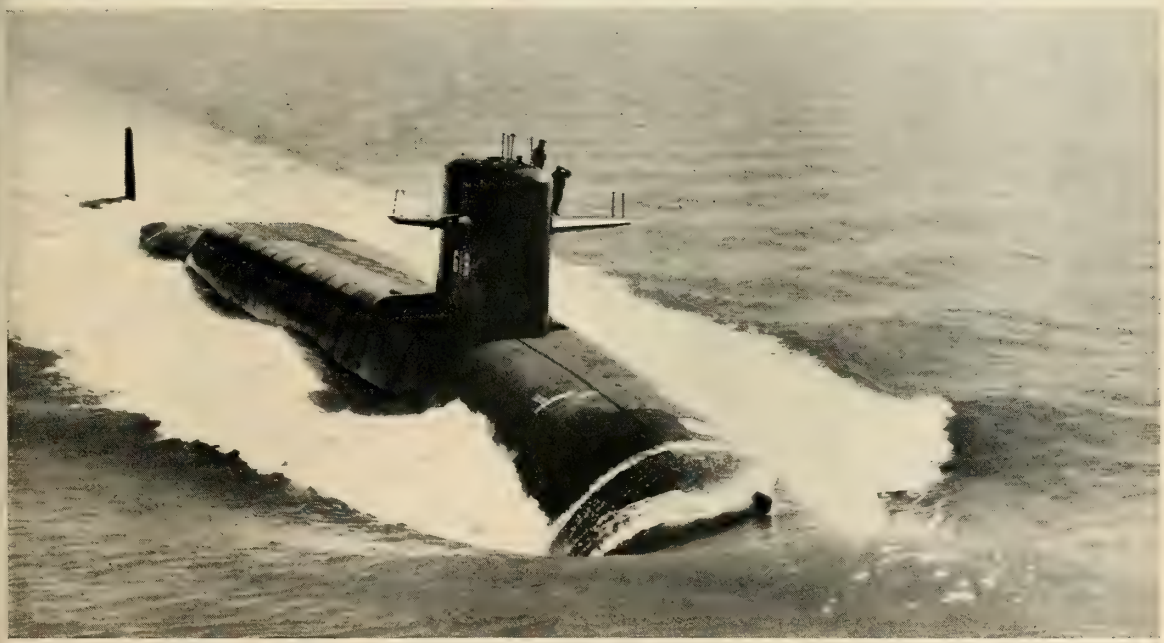

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NASA to loft *Surveyor* in tests of its retro-motors. There is believed to be so little time left now, however, that the first *Surveyor* flight will be launched for the Moon without suborbital tests.

● **Cost is persuasive**—Convair sees *Little Joe II* as a low-cost, in-being test truck for lofting a variety of large and heavy payloads of 80,000- to 100,000 lbs. on suborbital flights. Spokesmen point out that cost of the entire *Little Joe II* program is less than the cost of one *Apollo* payload it was designed to test. "Its economy makes it desirable for small as well as large payloads. An added advantage is the booster's potential for giving NASA the ability to make launches and recoveries on land."

Extensive facilities already exist at White Sands Missile Range, N.M.

Latest proposal for use of the vehicle is testing of the *Apollo* Service Module propulsion system at NASA/White Sands. NASA/WSMR is making a comparison of *Little Joe II* and a static test stand in an altitude chamber for this purpose.

Further potential uses include space environmental tests (zero and negative g, acceleration, low-pressure), aerial sled tests, dynamics tests (dynamic pressure, structural shell strength, aerodynamics, flutter), and systems tests (escape systems, reaction and retro-motor ignition and control, staging, jettison, parachute and similar systems).

Tools and fixtures remain available for manufacture, and two of the fixed-fin version vehicles are in storage with no planned missions for them. A spare launcher also is in storage and available immediately for other programs.

● **Saturn recovery**—For the *Saturn* S-IC stage recovery demonstration, Convair would team with Northrop in a program using *Little Joe II*, which is a two-fifths scale model of S-IC, to show feasibility of recovering the *Saturn* stage with a parachute system in a water landing. NASA/Huntsville is working up a program to investigate S-IC recovery possibilities. Candidate approaches for this include use of *Little Joe II*, *Redstone*, *Atlas* and dropping of a 1/10 scale model from an aircraft.

LITTLE JOE II, a two-fifths scale model of Saturn S-IC stage, used to show feasibility of recovering the stage with a parachute system.

For planning purposes, NASA is assuming that S-IC may be used for a large number of launches over the next decade, in which case recovery and refurbishment could enable large savings.

In answer to a request for quotations from Langley, Northrop has submitted a proposal on testing of the Mars lander system that includes use of *Little Joe II*. There is no firm plan for such testing of the Mars lander, but it is believed tests of the system at 150,000-200,000 ft. above the Earth would approximate atmospheric conditions at the Mars surface.

An informal proposal has been made to Jet Propulsion Laboratory for similar testing of the *Voyager* vehicle.

Use of *Little Joe II* was included as part of a proposal by Aerospace Corp. and McDonnell Aircraft to Air Force for testing of the *MOL-Gemini* configuration, which reportedly will use an escape-tower abort system.

● **Man-rating considerations**—In the *M-2* lifting body program, the NASA Flight Research Center at Edwards Air Force Base has written a report concluding that *Little Joe II* could be used to boost the vehicle into its re-entry corridor.

Since the *Little Joe II* structure was designed to man-rating criteria developed by NASA, it could be man-rated with addition of an emergency detection and abort system, but NASA has rejected a proposal for a manned *M-2* flight using *Little Joe II*.

It is believed that support for extending the life of *Little Joe II* could come from the fact that it would give NASA a continuing overland launch capability.

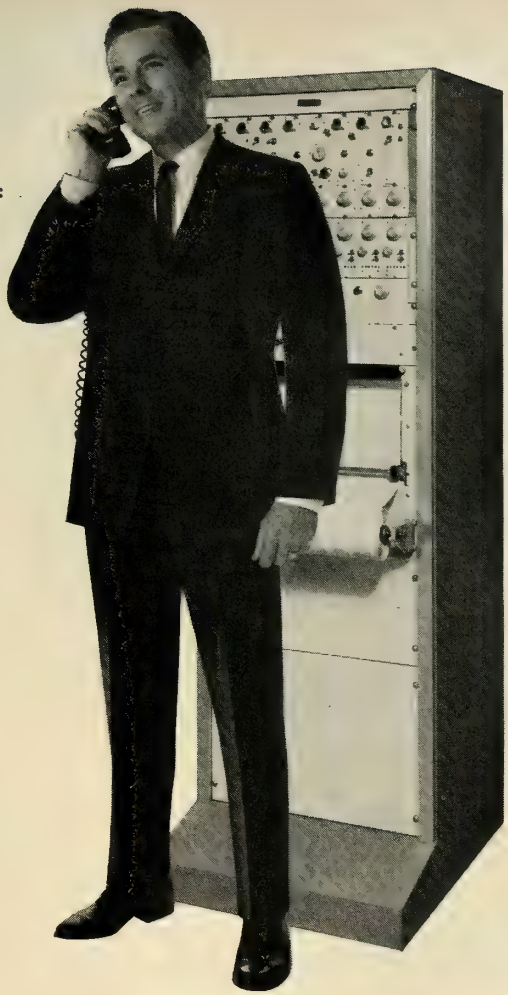
Unless the booster is utilized for other purposes, the White Sands facilities will be abandoned. Unless NASA has need for one of the *Little Joe II* backup vehicles it has ordered, the program will phase out this year. There has been some informal discussion of firing overland between Edwards and WSMR, enabling recovery of vehicles on land for examination following test.

● **Boosting thrust**—Uprating of *Little Joe II* could be accomplished with a 44-in. dia. motor Aerojet has designed, providing 50% more impulse than the present motor.

The 44-in.-dia. Aerojet motor proposed to uprate the vehicle with a minimum amount of rework is still on paper. The Algol 2B motor exists, and would provide 25% more total impulse. Currently, a peak thrust of about 850,000 lbs. is provided by seven 40-in. Algol 1D solid motors stage fired in an overlapped four-three arrangement. Various combinations of Algol and Thiokol Recruit solid motors can be used with different firing sequences to provide an optimum thrust combination for a wide variety of missions.

Projected costs for *Little Joe II* vehicles, less motors, are $450,000 for fixed-fin version, plus $150,000 for operations; $750,000 for the controllable version, plus $250,000 for operations. Current Algol motors cost $100,000, and Recruit motors run $4,000. Estimates are that up-rated vehicles would be available six to nine months after program go-ahead, with launch one to two months after delivery. ■

GOOD NEWS REPORTS:



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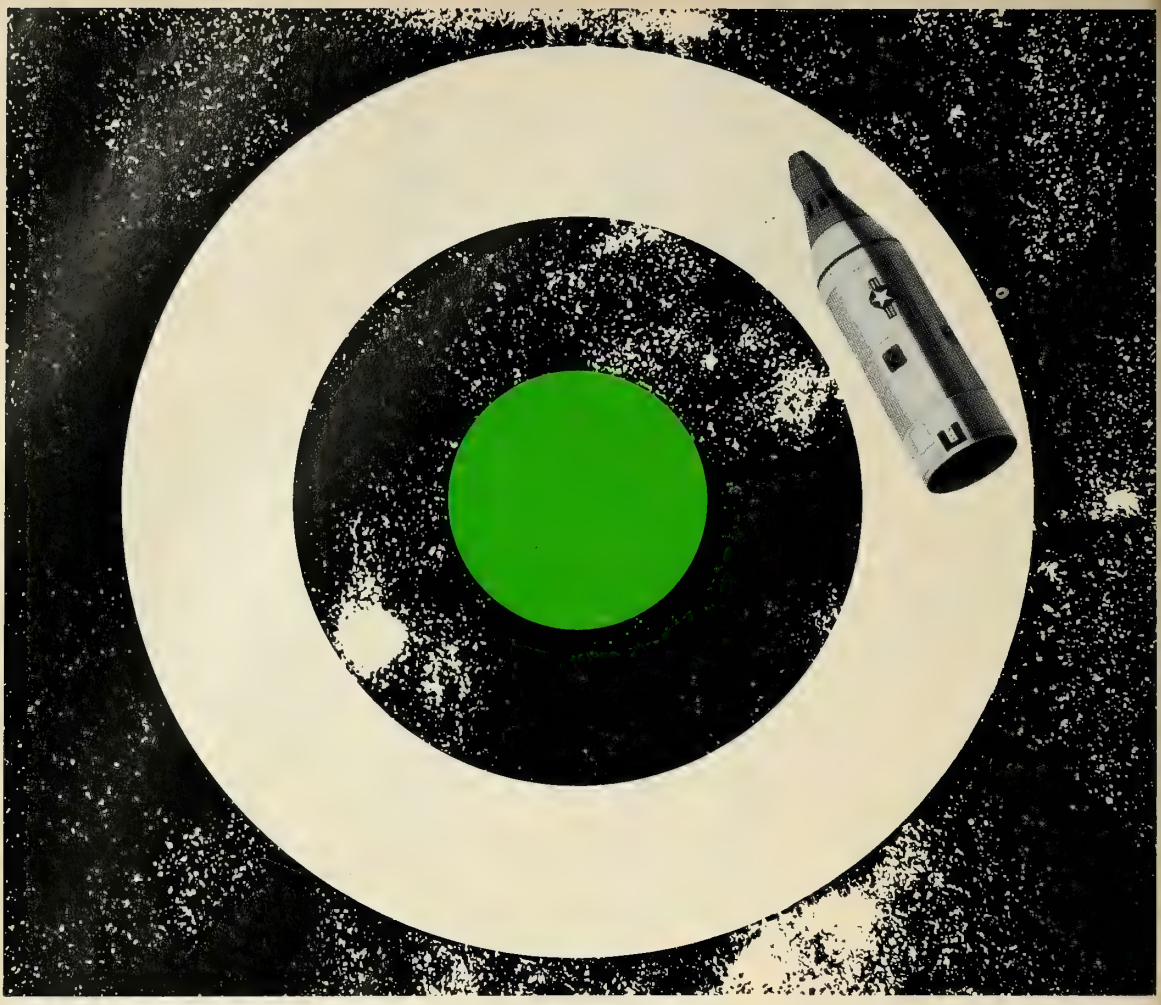

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Thermal Manikin To Aid MSC

Device, made by Arthur D. Little, will relieve astronauts from time-consuming, sometimes dangerous spacesuit testing

by Michael Getler

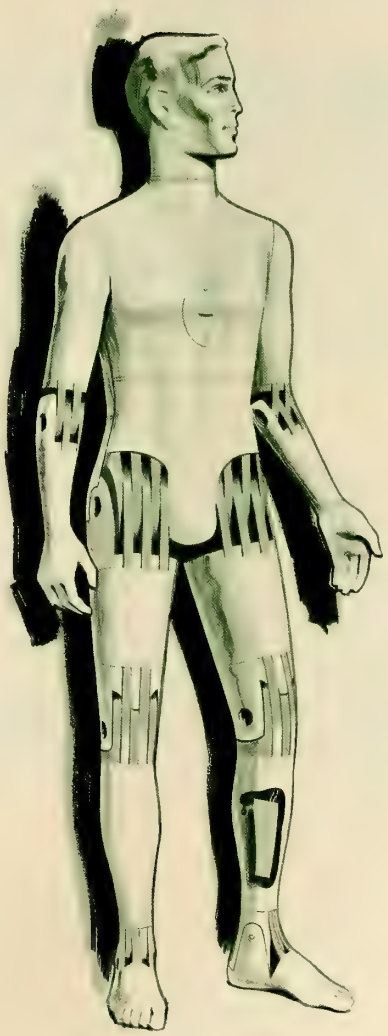
CAMBRIDGE, MASS.—An instrumented fiberglass and aluminum thermal manikin designed to simulate an astronaut's thermo-regulatory system and gather data on temperature effects in 17 regions of the body is being developed for NASA by Arthur D. Little, Inc.'s Division 500 here.

The manikin, to be delivered to the Manned Spacecraft Center in Houston in September, should serve as an important research tool in testing of *Gemini*, *Apollo* and post-*Apollo* spacesuit designs. Although it is not intended to completely replace the astronaut in-suit testing, it is hoped that a device of this type will relieve the astronauts of many of the rigors, potential dangers, and time-consuming chores involved in preliminary design and space-chamber checkout of new spacesuits.

Sized to represent a 50th percentile man (average Air Force flight personnel size), the manikin is cast in aluminum from a basic manikin form, using fiber-wrap techniques to build it up to a representative physique. It is divided into 17 regions, each thermally isolated from the adjoining area. Separate heating elements are installed on the inside of each section so that uniform heating can be established throughout that section. More importantly, the individual heaters will make it possible to simulate the actual temperature variations present in a human being, as well as the regulatory processes of the human which are made during adjustment to a change in environment.

While man's average body temperature may be 98.6°F, his chest region, for example, will always be warmer than his extremities. In some situations, such as that of a bather standing in cold water with the top half of his body exposed to the Sun, the discrepancies are larger. The human system makes some adjustments to these situations in an attempt to restore equilibrium.

Within a temperature range of 82-87°F, called the "comfort zone," the thermal mechanisms of an unclothed man are relatively inactive. In the "zone of thermal neutrality,"

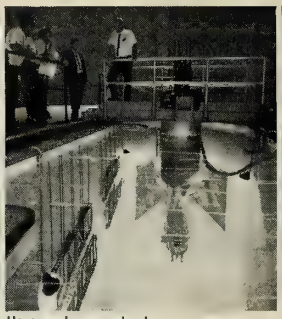


MANIKIN is designed to simulate astronaut's thermo-regulatory system and gather data on temperature effects in 17 body regions. It is made by Arthur D. Little, Inc.

Here are a few of the things Northrop does:

Makes U.S. Army's only operational surveillance drone, the camera-carrying SD-1.

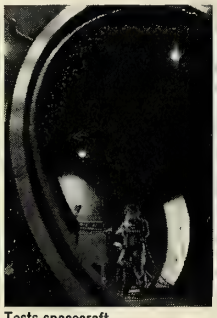
Developed earth sensor for Ranger lunar vehicle.



Uses nuclear reactor to determine effects of space radiation on men and equipment.

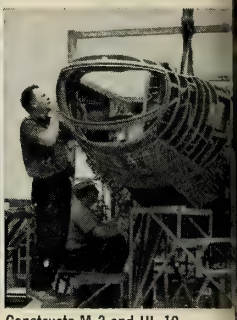
Makes metal architectural components for homes, factories, commercial and public buildings.

Provides recovery systems for Apollo and all manned space vehicles.

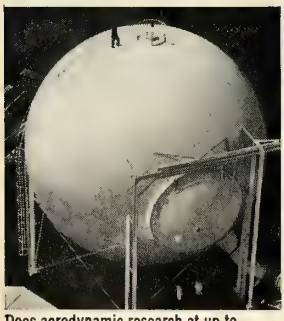


Tests spacecraft systems in man-rated environmental chamber.

Builds F-5 supersonic tactical fighters for America's allies.



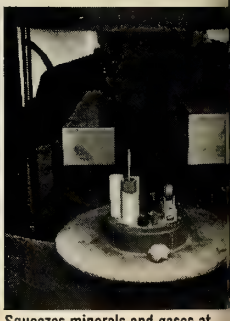
Constructs M-2 and HL-10 lifting body research vehicles for NASA.



Does aerodynamic research at up to 14 times the speed of sound in hypersonic wind tunnel.

Studies problems of human beings living and working in space.

Designs and builds worldwide communications systems.



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supersonic trainers
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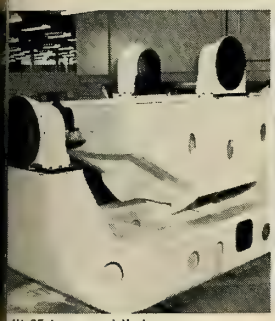
Designs
vehicles to roam
the moon.

Conducts
high-energy accelerated
plasma studies.



uilt 25-ton mount that can
ign NASA tracking telescope
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and space-borne computers
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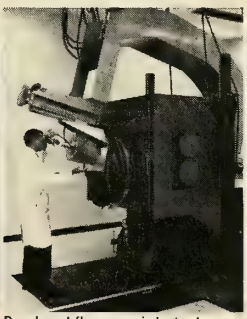
subminiature gyroscopes for
guidance and control systems.



Developed fluoroscopic tester to
examine aerospace components
under extreme flight conditions.

Developed NV-101
autogyro utility drone for
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Northrop scientists and engineers are at work on more than 80 important projects and programs in environments that range from the depths of the sea to the outer reaches of interplanetary space.

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75-90°, adjustments are made by constriction or dilation of the blood vessels. Sweating becomes an important factor above 90°, and at low temperatures man's metabolic rate increases and skin temperature decreases to maintain thermal balance.

● **Tailored dissipation**—ADL scientists stress that spacesuit designers must take man's native thermo-regulatory capabilities into account when designing protective clothing for astronauts, "and must reject the notion that he can be protected by a heated suit that will keep all the body parts at a single constant temperature. The clothing must be literally programmed to reflect and react to the metabolic processes that are at work within the astronaut's system."

Manikins previously used for thermal testing have been of the "copper-man" variety, in which a constant average temperature is maintained throughout the form.

"The problem of spacesuit design," says ADL's Frank Gabron, "is not one of a total rate of heat dissipation but of tailoring individual areas of the suit to the rates that exist there." For example, poor design in a boot could be recognized more quickly in a thermal manikin of the type now under development, wherein regional processes are reflected, than in an average-temperature manikin. This carries a dividend in safety, since a poorly designed suit segment could freeze a human foot in seconds in an environmental chamber test.

The heating elements in the ADL system in effect simulate the metabolic rates of the astronaut, and platinum resistance thermometers attached to the manikin's skin provide read-out of skin temperature measurements.

Once in a chamber, the sensors and elements are connected via a hard-wire hook-up to a digital data system. Changes in skin temperature will signal programmed changes in power, simulating metabolic rate in Btu/hr., which are required to bring the manikin back to a state of equilibrium. The power changes will be recorded automatically. ADL says the low thermal mass of the manikin will make it possible to achieve this new equilibrium much more rapidly than would be the case with human subjects, whose systems react more slowly, and therefore could also shorten test periods.

The initial system is being programmed to NASA-Houston specifications, but the primary data used is that collected by the Royal Air Force Institute of Aviation Medicine during experiments measuring regional metabolic rates for a normal man at rest. ADL scientists are hopeful that additional data for the same conditions will be obtained with human subjects in this country to refine and/or corroborate the RAF measurements.

● **Only beginning**—The manikin's usefulness is expected to increase significantly, with the expansion of data taken in ancillary experiments with human subjects under varying conditions. Many scientists feel that the data now at hand regarding bodily reactions to different degrees of activity, the transition from rest to activity, or rapid temperature differentials, is rather scanty. All of these conditions could easily be present in manned space missions involving extravehicular activity.

To simplify the task of getting the ADL manikin into and out of spacesuits, it will be assembled so that the extremities are removable. Its joints contain innovations which designers here feel will significantly improve spacesuit checkout—and which also could make important contributions to prosthetic limb design for medical use.

The joints are movable, so that the manikin can be placed in any position, and also feature a unique type of pneumatic locking to keep them in that position. They are engineered to avoid pinching off of any water-cooled lines in an astronaut's undergarment when limbs are moved.

The manikin's isothermal characteristics also grow out of joint design. Alternating layers of aluminum and micarta are arranged so that the external portion of the joint will continue to reflect the temperature of the region it is in, while the micarta insulates that regional temperature from the adjacent one.

Although current NASA spacesuits for the *Gemini* and *Apollo* missions use active environmental control, ADL scientists feel that the manikin will be useful in the development of other suits in which the thermal control properties are essentially passive. In the latter case, the needed regulation is provided by the design of the suit, rather than the suit in combination with environmental conditioning equipment. Passive-control suits could reduce the equipment to be carried by an astronaut and thus increase mobility.

The Air Force is supporting an ADL program researching the potential for passive suits, possibly involving multilayer foil designs which can control heat loss by varying the pressure between layers with a manual venting scheme.

● **No sweat**—There is another factor of suit design in which ADL feels the manikin may play an important part. Current suits are designed mainly to keep the subject on the cool side of the comfort zone—primarily to avoid sweating, which can pose a problem of water removal. ADL scientists point out, however, that there is sometimes a very narrow margin between these zones; a suit that is perfectly comfortable for a man at rest becomes uncomfortable as he begins to work, and sweat.

For this reason they stress the need for more data on human regulatory system operation during periods of work. There are also other factors which can make a man sweat—fear, for example. ADL scientists believe that the manikin may allow NASA to move a little more freely toward designing a suit in which sweating presents no problem. ■

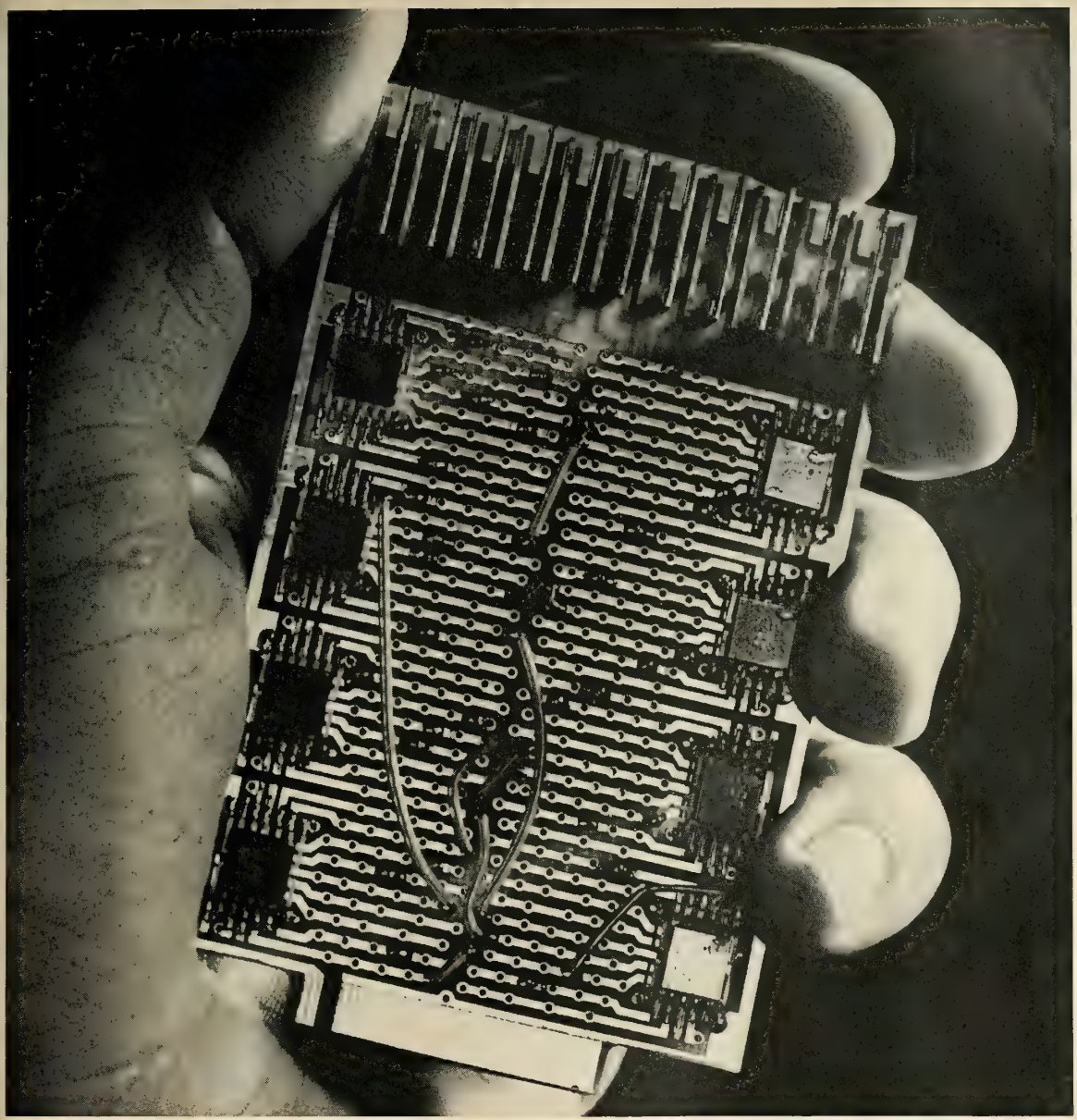
Three-Grain Solid Pulse Motor Tested

AEROJET-GENERAL reports a 100% successful program so far in demonstrating feasibility of a three-grain solid pulse motor for tactical application. The Sacramento plant has fired six 15-in.-dia motors of two or three grains under an Air Force research contract.

The stop-start motors utilize conventional, internal-burning grains as opposed to the end-burning wafer design effort Air Force has funded at Lockheed Propulsion Co. The latter has been proposed for use in *SRAM*. Key to design of the Aerojet motor is a thermal barrier between the grains that holds grain temperature to 200°F while an adjacent grain burns at 6,000°F.

With emphasis on tactical weaponry and upcoming need for multi-start capability for space exploration missions, Aerojet has been devoting considerable effort to stop-start and controllability in solids. One approach is use of a pintle nozzle plug positioned in the center of the throat. Movement of the plug aft increases throat area and rapidly drops chamber pressure to extinguish the motor. Use of a liquid igniter hypergolic with the grain permits many restarts. Thrust can be varied by selective positioning of the plug.

For application to missions requiring pre-established variable thrust programs, the company has proposed a design for a solid motor in a doughnut configuration utilizing an internal-burning grain. Exhaust gases are expelled through a convergent-divergent nozzle producing a constantly increasing thrust level to burnout.



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DATA ACQUISITION SYSTEMS

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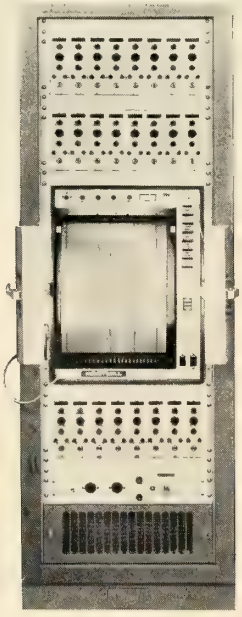

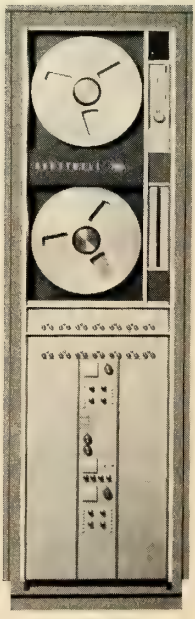

Temperature-Resistant Quartz Produced

Tests indicate Stevens-developed 'Astroquartz' may outperform glass fiber, graphite and high-silica fabrics in ablation role

by John F. Judge

A SERIES of comparative ablation tests performed by the CTL Div., Studebaker Corp., indicates a new quartz material may outperform conventional glass fibers, graphite and high-silica fabrics in high-temperature applications.

Developed and marketed by J. P. Stevens & Co., the material family is designated Astroquartz. The members are composed of pure quartz fibers having a silica (SiO_2) content of 99.95%.

The two Astroquartz specimens tested by CTL were plain-weave fabrics impregnated with CTL 91-LD phenolic resin, molded at 100 psi and 280°F for one hour with no post-cure. Astroquartz/graphite composites were also examined.

The test program resulted in comparative information typified by the comparison of surface recession rates of quartz and glass-laminated specimens.

The CTL report cites the performance of the quartz fabric as ". . . without doubt, rather impressive as an ablative, insulating mechanism." "The quartz material," continues the report, "to a larger extent than any of the other materials tested, resisted the combined erosion effects from thermal degradation, chemical reactions, as well as from shear forces generated by the flowing environmental gas, pressure forces from the gas generated at the char-virgin interface and thermal stresses set up by the temperature gradients in the solid material."

The CTL researchers found the quartz also demonstrated an ability to prevent heat from penetrating the interior—a factor in protecting substrate structure and payloads.

● **Instrumentation**—The tests were handled in CTL's arc plasma generator test facility. A channel flow test method was used—with a specimen opposing a cold-wall calorimeter.

A 36-channel Honeywell Model 1612 Visicorder oscilliograph captured all pressure, temperature and electrical test data. Transient temperature response from the thermocouples embedded in the specimens was recorded and monitored throughout the duration of each test to define internal material behavior.

Specimen surface temperatures were determined by a Leeds Northrop total radiation pyrometer and a Latronics Coloratio pyrometer. Outputs of these instruments were recorded by the Honeywell 1612.

Surface liquid layer motions were studied through photography. Mass loss measurements—both physical dimensions and specimen weight changes—were used to evaluate recession rates and effective heats of ablation for specimens experiencing ablation.

None of the tests involved variations in the thermal environment to individual specimens. Thus the tests were a measure of the gross effects of the conditions and the evaluation of material behavior should be taken as a qualitative comparison.

Each test lasted 30 seconds with a heat flux of 240 BTU/ft.²/sec. Simulated air was used as the test gas. (Refer to Table I for specimen composition.)

● **Post-fire analysis**—In the discussion of their results, the CTL investigators noted that Specimen A-1-1 post-firing thickness was slightly greater than the initial dimension. This is the reason for computing the heats of ablation on the basis of the gravimetric method rather than recession rates.

The relatively poor showing of the Style 182 glass was explained by the CTL experts as being based on some reaction which removes carbon from the char formation. This evolved from the observed surface condition of the sample, which consisted of pearl-grayish globules and several clusters of siliceous material. The material in this reaction could also be viewed as a heat sink.

The graphite-laminated specimen has a greater mass loss than the graphite-quartz sample. But the graphite-quartz specimen indicated a lower recession rate than the graphite sample.

CTL experts thought this was significant, since both graphite and quartz have almost the same specific heat and only the graphite was exposed to the shear environment of the plasma stream.

The report states that the phenomena may be attributed to the open weave pattern of the quartz laminates—which allowed the flow of evaporating gases from the specimen's interior with a cooling effect on the char formation.

For all practical purposes, continues the report, the quartz, 182 glass, and high silica indicate the same high insulation value. The maximum temperature rise amounted to 8°F—compared to a temperature rise of 122°F exhibited by the WCJ graphite specimen.

The quartz graphite composites indicated a maximum temperature rise of 35°F with the 733 quartz fabric and a 16°F rise with Style 533 quartz fabric.

TEST SPECIMEN DESCRIPTION

SPECIMEN NO.	SPECIFIC GRAVITY	RESIN CONTENT %	RESIN	REINFORCEMENT
A-1-1	1.67	25.6	CT 91-LD phenolic	533 quartz fabric plain weave 18 x 18 count
A-1-2	1.66	24.4	CT 91-LD phenolic	733 quartz fabric plain weave 18 x 36 count
A-1-3	1.22	42.2	CT 91-LD phenolic	Graphite fabric plain weave 21 x 21 count
*A-1-4	1.58	——	CT 91-LD phenolic	Graphite fabric plain weave 21 x 21 count 733 quartz fabric plain weave 18 x 36 count
*A-1-5	1.58	——	CT 91-LD phenolic	Graphite fabric plain weave 21 x 21 count 533 quartz fabric plain weave 18 x 18 count
A-1-6	1.98	19	CT 37-9X phenyl Silane	182 glass fabric 8H Harness weave 60 x 56 count
CT-421	1.7	32%	CT 91-LD phenolic	84 type silica (leached glass fabric)

NOTE: All specimens 4 x 1 x ½ in., molded at 100 psi, 280 F, for one hour, no postcure.

* Composite specimens consisting of ⅜ in. quartz laminated fabric and ⅛ in. graphite laminated fabric. Graphite fabric laminate was the wetted surface to provide uniform heat transfer to the quartz laminations.

Both cases emphasize the low value of thermal conductivity of the quartz fabric.

● **Market specifications**—Astroquartz filaments retain the properties of solid quartz. The yarn is perfectly elastic and its elongation at break is 1%. A wide variety of fabrics can be made by Stevens—from 2.5 to 24 oz./sq. yd. and in thicknesses ranging from 0.004 in. to 0.020 in. Yarns can be oriented to produce both unidirectional and bi-directional types.

The material does not melt or vaporize until the temperature exceeds 3,000°F. At continuous temperature exposures in the 1,900°F area, Astroquartz begins to de-vitrify into the crystalline form known as Critobalite. This stiffens the material, but no other changes have been noted.

Astroquartz will melt into a pasty form at 2,370°F and vaporizes at 3,600°F.

The structural strength of the Astroquartz family is considerably higher than that of comparable silica laminates. Style 581 reinforced laminates have a flexural strength of 82,000 psi against 20-24,000 psi for similar silica materials.

ARC PLASMA TEST CONDITIONS

SPECIMEN NUMBER	TOTAL ENERGY BTU/SEC.	ENTHALPY BTU/LB.	CHAMBER PRESSURE PSIG
A-1-1	585.0	3510	9.00
A-1-2	483.9	3429	8.25
A-1-3	482.2	3650	8.25
A-1-4	482.2	3570	8.25
A-1-5	482.2	3210	8.50
A-1-6	487.7	3295	8.75
CT-421	(Fired under similar conditions but not at the same time)		

ARC PLASMA TEST RESULTS

SPECIMEN	RECESSION RATE, IN./SEC.	MASS LOSS RATE, LB./FT.² SEC.	MASS LOSS PERCENT	EFFECTIVE HEAT OF ABLATION BTU/LB.
A-1-1	Nil (intuemscent)	0.00863	6.053	27,810
A-1-2	0.00020	0.00749	5.173	32,043
A-1-3	0.00143	0.01731	16.528	13,865
A-1-4	0.00116	0.01640	12.528	14,634
A-1-5	0.00120	0.01740	13.133	13,793
A-1-6	0.00522	0.05180	30.380	4,633
CT 421	0.00317	0.01462	14.711	21,300

Several prime missile firms have shown interest in the material family—to the extent of testing in developmental rockets. Astroquartz is available in pre-impregnated forms from U.S. Polymeric under the designation X-200—a quartz fabric prepreg using an elastomeric phenyl silane resin with proven latent cooling abilities. ■

advanced materials

Chemical Color Coating Is Promising

A PROCESS for depositing engineered-color materials on selected metals to control temperature and prevent outgassing in the space vacuum may move immediately into commercial usage.

The low-cost chemical process was developed by Dr. F. J. Schmidt, manager of space power at General Electric's Re-entry Systems Dept., as a means to control the temperature on space vehicles. The coating also makes the metal surfaces extremely resistant to the constant, minute degradation caused by the hard vacuum in space.

In addition, the technique can:

—Put any color permanently onto the surface of aluminum for building construction panels or boat, aircraft and car bodies. The coating will not chip, crack or fade.

—Apply a velvet-black smudge-proof surface around the outside bottom of aluminum cookware with a resultant increase in heat-soak ability.

—Permanently incorporate non-stick materials onto metal surfaces.

—Substantially increase the hardness and scratch resistance of soft metals, such as aluminum.

● **Process proprietary**—Schmidt did not disclose details of the process because GE is negotiating licensing agreements with both domestic and foreign firms.

Treated samples have been exposed to vacuums in the 10^{-7} torr range for several weeks with simultaneous high-intensity radiation and 600° F temperature levels. The samples showed no evidence of deterioration from outgassing or other environmental exposure.

Samples have also been heated to 900° F and suddenly chilled to —320° F in cyclic tests without causing chipping, flaking or color changes. Specimens have been hammered, machined, bent and otherwise abused with the same result.

● **Broad application foreseen**—The process may be developed to apply to any metal through further research, but it is currently used with aluminum, magnesium, beryllium, tantalum and columbium.

Several pieces of metal have been coated to be used inside a vaccum chamber being built by GE's vacuum products dept. Parts of the vacuum chamber liner were treated to give them near-black-body characteristics.

A spacecraft infrared stimulator using the Schmidt process is now being built for the *Nimbus* program. The stimulator must operate at 600° F without undergoing a color change.

● **Color blending possible**—Schmidt says it is possible to blend a variety of hues and colors onto metal surfaces in one step. This requires a relatively simple control system for dispensing more than a single color.

For example, Schmidt says the controlled mixing of yellow and blue can produce a color flow from pure yellow through green and even to a bluish olive.

With three basic colors, a complete range can be produced.

The process is far more flexible—and possibly cheaper—than conventional painting and dying procedures. In addition, the extreme resistance to failure in mechanical working means that products can be fabricated from pre-colored sheet stock.

Schmidt has also developed a process of electroforming highly reflective mirrors from aluminum instead of electro-depositing the metal onto a nickel substrate. (M/R, July 13, p. 27). ■

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COMPLETE LINE OF FILM READING

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SEC. A MAY, 1965 VOL. XIV

As a result of Benson-Lehner Corporation's recent acquisition of Data Instruments (Telecomputing), a Division of the Whittaker Corporation, Benson-Lehner now ranks as the **leading** manufacturer of film reading devices, offering the **most complete line** of film readers available. By combining over 30 years of film reading experience, Benson-Lehner now has the capability to handle any film reading application.

BENSON-LEHNER 29E TELEREADEX . . .

The 29E is the **only** film reader offering front projection. This unique feature reduces optical parallax by allowing the operator to position the crosshairs on the same focal plane as the projected image.

Any film size from 8mm to 140mm including 10″ x 10″ cut film or 10″ x 10″ ballastic plates can be projected and read on the Benson-Lehner 29E Telereader.

BENSON-LEHNER BOSCAR S . . .

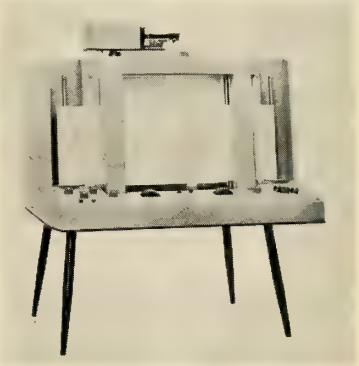
The BOSCAR S, designed for ease of operation, is the fastest semi-automatic film reader available today. Featuring the unique single control for X and Y, The BOSCAR S can be operated at speeds over 600 frames per hour for normal applications. A completely solid state design makes the BOSCAR S reliable for rugged, high volume film reading applications.

OSCAR S-2 . . .

The largest selling film reading system in the industry today, the OSCAR S-2 combines accurate film reading capability with the additional capability of handling oscillograph records. The OSCAR S-2, completely solid state, has maintained an operating efficiency of over 98% "up-time." This economical system featuring automatic zero offset can handle the majority of your film reading applications.

FOR THE LESS DEMANDING JOBS . . .

Benson-Lehner also offers the Universal Reader and the Oscar F systems. These inexpensive systems are being used throughout the industry to provide film reading for those who do not require the extreme accuracy of the larger systems.



Oscar S-2

OUTPUTS . . .

All Benson-Lehner readers feature output to punched cards, typewriters, punched paper tapes, or computer compatible magnetic tape.

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Benson-Lehner maintains the largest service organization in the data reduction industry. Over 50 factory trained field engineers are on call throughout the entire United States.

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Univac Delivers A-NEW Computer

Unit, developed in less than 10 months, is designed for use in air, surface or underwater manned military tactical systems

by Charles D. LaFond

AN ALL-MICROELECTRONIC, high-speed, high-capacity computer, designed for flight use in the Navy's A-NEW (airborne ASW) program was delivered last week. It was developed in less than 10 months by the Univac Division of Sperry Rand Corp., which claims it will be applicable for use in any military manned tactical system—air, surface, or underwater.

The initial $1.3-million contract was awarded Univac by the Naval Air Development Center (NADC), Johnsville, Pa., in June, 1964. Called the Univac 1830 by developers, the digital system is now designated the CP-823/U by the Dept. of Defense. Development was managed by NADC for the Navy Bureau of Weapons.

The new system occupies some 8 cu. ft. in its maximum configuration. Univac says it is directly equivalent in performance to its predecessor, the CP-642B, which uses more conventional solid-state circuitry and occupies 58 cu. ft.

Only one system was built and delivered under the contract, but Univac officials disclosed that it is configured as a production model and that future systems will be commercially available—with guaranteed six-month delivery.

Due for early testing at Johnsville, the CP-823/U will be integrated with other A-NEW Mod 3 Airborne Test Systems and is scheduled for flight-testing early next year by the Navy. It will serve as the primary data processor for the A-NEW aircraft's ASW sensory, fire control and supporting electronic subsystems.

● **Large memory capacity**—Univac officials describe their new system as "being the fastest, having the most words in storage and providing the largest instruction repertoire" of any computer of similar size now in existence.

The 50-lb. central processor measures roughly 7¼ x 14½ x 17½ in. overall. Its control section interprets up to 62 instructions, carries out commands, provides timing, and controls or directs the program sequence.

An arithmetic section follows this direction in the performance of arithmetic and logic functions. It is provided with four 30-bit parallel input/output channels to match specific I/O needs.

The control structure includes seven index registers, seven branch designators and seven operand interpretation designators.

Typical execution times include:

Add or subtract	8 μsec.
Multiply	32-48 μsec.
Divide/Sq. Root	48 μsec.

Silicon integrated circuits are employed throughout the central processor, and discrete component circuits are used only in portions of the memory circuits. Of some 2,500 chips employed in the 69 logic boards, 2,400 are identical, Sperry said. Individual double-layered logic boards carry up to 64 chips with an average of 50 per board.

During the manufacturing process of each board, over 700 connections are made in one pass through a wave soldering machine. Developers say no retouch is required.

Tuning-fork multiple connectors are used on the logic boards.

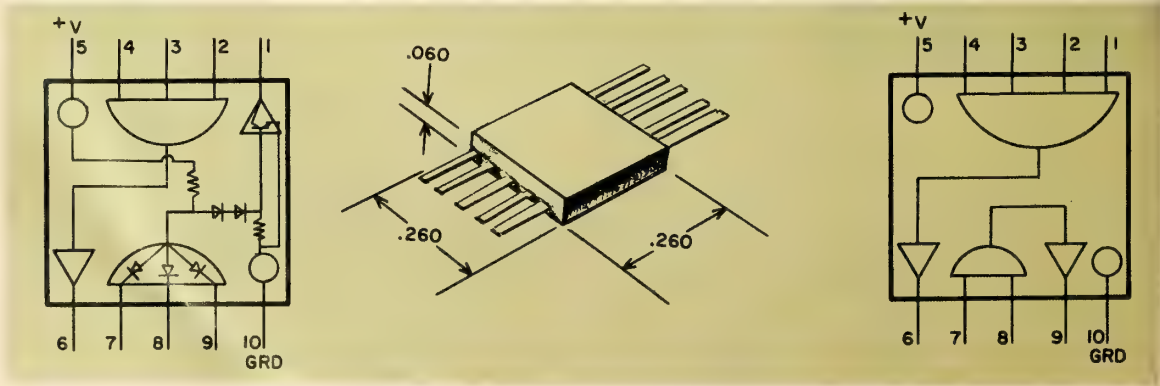
The 100-lb. memory unit, as delivered to NADC, is provided with both 4096-word magnetic thin-film memory and a 28,672-word ferrite core memory. The thin-film memory provides a nondestructive readout, the latter destructive.

Total capacity of the existing system consists of 32,768 words at 30 bits per word. Memory cycle time is four microseconds.

Ferrite cores are temperature-compensated 30 x 18-mil memory planes.

A 60-lb. power supply provides regulated d-c power for the computer. Three-phase, 400-cycle input at 200 volts is required, with power output varying from 285 to 845 watts, depend-

COMPUTER'S basic logic elements are NAND type, and 69 logic boards carry an average of 50 chips each of the designs shown.



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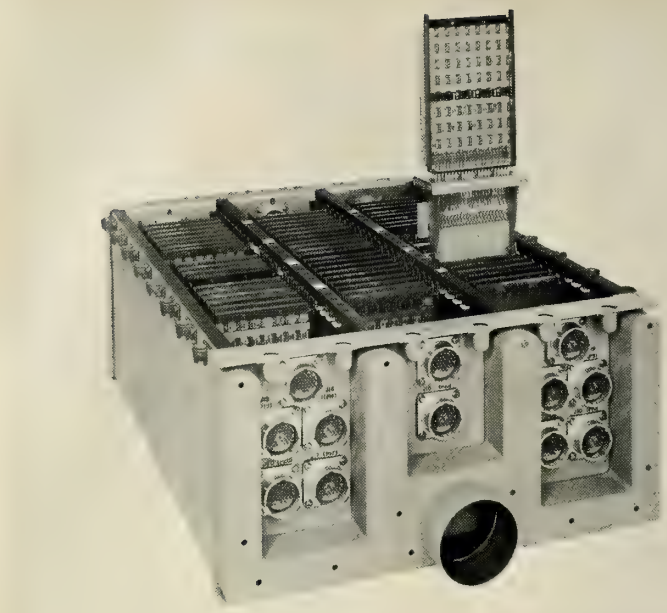


CENTRAL processor for CP-823/U with logic board shown raised on card extender.

ing on the particular computer configuration.

The CP-823/U Input/Output unit is a microelectronic multiplexer. Up to 16 channels can be provided in the simplex, 30-bit parallel-type subsystem. A single channel can handle up to 62,000 words (30-bit) per second and a multichannel rate of up to 125,000 wps.

It features full buffer and/or real-time control on each channel, supplies intercomputer communication with all channels, handles external commands, provides internal interrupt capabilities from buffer monitors on each channel, and performs a channel "active" test.

- **Memory modules**—Both the metallic thin-film and magnetic core memory unit are modularized in increments of 4096-word-capacity stacks.

Thin-film units are comprised of vacuum-deposited elements on a glass substrate. Two substrates mounted on an epoxy component board between copper conductors (etched on a Mylar base) comprise a memory plane. Several planes are stacked and sealed. The majority of associated memory electronics employs integrated circuit construction.

The 30 x 18-mil magnetic cores are packaged in a 2-window plane configuration. Thirty planes are packaged together with their associated electronics to provide a pluggable 4096-word module. Seven modules are used.

- **Compatibility**—The CP-823/U was designed to be compatible with other Univac military computers. With the change of a connector it can directly replace its predecessor, the CP-642-B.

(The new system was designed using the CP-642, a computer originally developed for the Bureau of Ships' Navy Tactical Data System.)

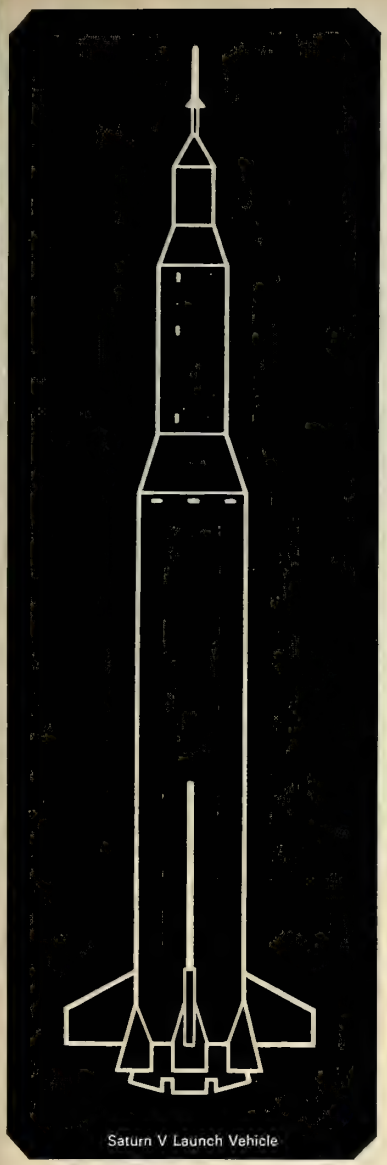
The Univac CP-642A/USQ-20(V) and the CP642B/USQ-20(V) computers employ the same instruction repertoire and input/output. Programs are interchangeable. Actually, the instruction repertoire was defined in 1959 by the Navy and is now being used in over 100 computers and at Naval data compilation centers.

- **Future sales**—Both the Bureau of Ships and Bureau of Weapons reportedly are considering buying limited quantities of the new Univac system.

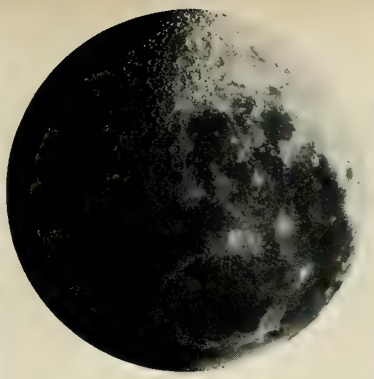
One government informant indicated that three separate orders for as many as 15 systems are now being considered. Since the basic CP-283/U will cost roughly $300,000, early contracts from the Navy alone could total in excess of $7 million, including spares and services. ■

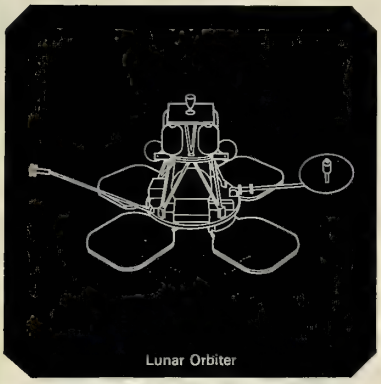
Saturn V Hardware Takes Shape at Douglas

FINISHING touches are put on first interstage section being fabricated at Douglas Space Systems Center, Huntington Beach, Calif., for Saturn V launch vehicle. Conical section is designed to join Saturn Douglas-built S-IVB stage to larger-diameter S-II stage. Interstage, more than 19 feet high, will house four retro-rockets to be fired for positive stage separation before S-IVB ignition. S-IVB is top stage of Saturn V and also of the smaller Saturn IB launch vehicle.

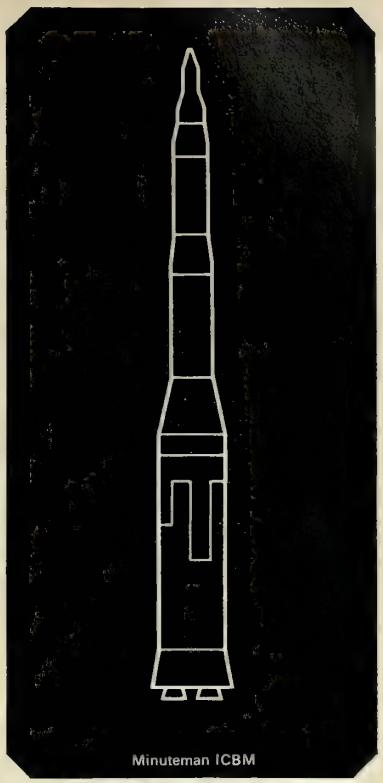


Saturn V Launch Vehicle



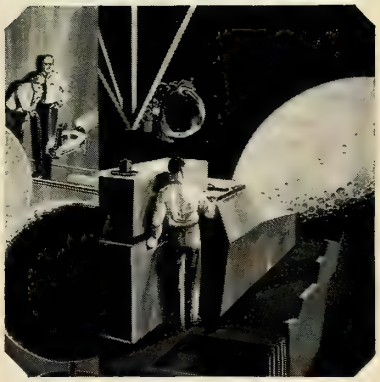


Lunar Orbiter



Minuteman ICBM

Space-Age Boeing Openings



Space Research

for Engineers and Scientists

The Boeing Company's Aero-Space Division, major contractor for the Saturn V launch vehicle, Minuteman ICBM and the lunar orbiter, has a number of challenging opportunities for graduate engineers and scientists. (See list in right-hand column.) Assignments, which vary with each Boeing facility, are at Cape Kennedy, Fla.; Huntsville, Ala.; New Orleans, La.; Seattle, Wash., and Vandenberg AFB, Calif.

Minimum requirements are a B.S. degree in an engineering or science discipline, plus applicable experience. Salaries are commensurate with your experience and education background. Travel and moving allowances are paid to newly hired personnel. Boeing is an equal opportunity employer.

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To achieve the required velocity measurement accuracy of 1 ft/sec at 35,000 ft/sec in the injection firing window, increased range tracking capability across the width of the launch corridor is required. One solution, now in the planning stage, is to slave two advanced instrumentation ships to an island-based station in a triangular configuration, maintaining minimum separation of 250-500 nm.

Complex problems in telemetry, navigation, tracking, communications, and data handling must be solved. Of paramount consideration are:

☐ systems to maintain precise time synchronization among stations and Central Control. ☐ systems to measure ship vertical and heading within 30 seconds of arc. ☐ systems to measure range and range rate to the required accuracy. ☐ systems to provide near real-time data handling and transmission among ship/land stations for rapid trajectory-correction information.

On this and other programs, assignments are immediately available to senior electronic engineers with *systems and planning* background in: pulse and CW radar/telemetry/optics/infrared/data handling/communications/closed circuit TV/frequency analysis/command control/underwater sound/timing/shipboard instrumentation.

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The Industry Week

Mergers and Acquisitions

GAP Instrument Corp., Westbury, N.Y., has acquired Microphysics, Inc., of Huntington, N.Y., a manufacturer of electro-optical incandescent readouts for use in industrial and military computing, data handling and information display systems. GAP makes precision digital/analog computer systems. Microphysics will operate as a subsidiary of GAP. . . . *Amphenol-Borg Electronics, Chicago, has acquired the principal assets of Jefferson Electronics, Torrance, Calif., a subsidiary of Jefferson Electric Co. Terms were not disclosed. Jefferson manufacturers wired assemblies and cable harnesses for a variety of uses, including missiles and space vehicles.* . . . The Adel Div. of General Metals Corp., Burbank, Calif., has acquired Vinson Mfg. Co., Inc., of Van Nuys, Calif. The acquisition includes Vinson's lines of hydraulic and pneumatic components and systems for missiles, ground support equipment and aircraft. Adel Div. specializes in the design and manufacture of hydraulic, pneumatic, fuel and electro-mechanical systems and power generating packages for military, commercial and private applications in aircraft and missiles.

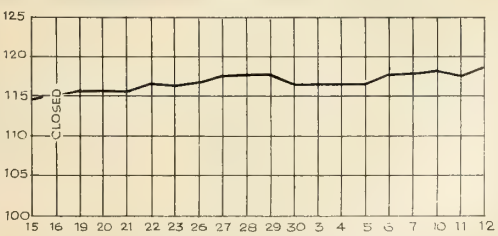
New Activities

Veeder-Root, Inc., Hartford, Conn., has formed a new division for the design and production of counters for precision instrument applications, including military. Headquarters for the new activity will be in Hartford in the firm's present plant. . . . *Microtek Electronics, Inc., Cambridge, Mass., has been established to supply electronics manufacturers with a line of microcircuits in the 20 to 500-mc frequency range. Since ME began RC network operation the last week of March, production capacity has reached the level of 20,000 networks and microcircuits per month. The firm plans to offer its first standard linear circuits.* . . . Electronic Associates, Inc., Long Branch, N.J., has formed EAI Instrument Div., to have complete responsibility for design, manufacture and marketing of EAI's X-Y plotters, digital voltmeters, digital acquisition systems, scanners and new instrumentation developments. . . . *The name of Westgate Laboratory, Inc., Yellow Springs, Ohio, will be changed July 1 to Arvin Systems, Inc. Westgate is a wholly owned subsidiary of Arvin Industries, Inc., Columbus, Ohio, and is a part of Arvin's Electronic Systems Div. Westgate presently produces X-Y recorders, digital micropositioning systems and nondestructive spot-weld testing equipment. The Westgate trade name will be continued.* . . . Westinghouse Electronic Corp.'s Sunnyvale (Calif.) Div. has established two groups to pursue new markets and to expand present ones. An engineering and programs group will match design, engineering and manufacturing capabilities of the Sunnyvale facility to customer needs. A special products marketing group is assigned to explore new industrial, scientific, defense and space markets that can use the plant's technical and manufacturing skills. . . . *Fairchild Camera and Instrument Co., Syosset, N.Y., has formed a new Instrumentation Div. in Clifton, N.J. It will combine the electronic equipment capabilities of both the Semiconductor and the Du Mont Laboratories divisions.* . . . Ling-Temco-Vought, Inc., stockholders, meeting for the first time in the company's new downtown Dallas headquarters on April 30, approved by a 10:1 margin a plan under which the firm organized three new subsidiaries as successors to the business and operations of eight former divisions (M/R, Feb. 15, P. 45). Primary purpose of the plan was to provide increased flexibility for future growth by decentralizing management and increasing autonomy and specialized identity of the subsidiaries.

Facility Expansions

The General Electric Co. has leased the existing facilities of the New York State Atomic and Space Development Authority's Malta Test Station for rocket development and testing at Ballston Spa, N.Y. G.E. will operate the station through its Mississippi Test Support Operation, a department of the G.E. Missile and Space Div. Under terms of the three-year lease, the Authority retains the right to install new facilities at the station not occupied by present structures and to provide separately for the operation of such new facilities. The lease is renewable until Dec. 31, 1975. . . . *Westinghouse Electric Corp. has opened a research facility in Albuquerque, N.M., to conduct research in the development and testing of programs for computer-based educational systems and related instructional techniques. It will operate as the behavioral technology department of the Westinghouse Research Laboratories.* . . . Ramcor, Inc., designers and manufacturers of microwave components and instrumentation, has moved from Hicksville, N.Y., to a new 30,000-sq.-ft. plant in Huntington, N.Y. . . . *Sunbeam Electronics has moved its operations from Racine, Wisc., to a new $3-million plant in Fort Lauderdale, Fla. The move climaxes a two-year expansion and reorganization program at Sunbeam.*

Missile/Space Stock Index



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

SYSTEMS MEN:

MITRE has immediate openings for work on important national projects

MITRE works on the frontier of large-scale system design. We design and engineer information, sensor, command, control, and communications systems, and develop new techniques in these areas which contribute to the advancement of the general technology.

There is now an opportunity for qualified people to work on projects of national importance. Your challenge at MITRE will be to mate present and predictable technology to operational and future military and air traffic control systems. You and your associates in MITRE will work on a broad spectrum of military problems and the technologies needed to solve them. You will work with the military and technical people who are the leaders in the design, engineering, and acquisition of many of the nation's most important military systems.

OPENINGS IN THE FOLLOWING AREAS:

COMMUNICATIONS — We need people who can help conceive new communications systems, recommend development programs to achieve these, and analyze special communications requirements generated by new systems concepts. Work areas include systems planning, analysis, simulation and design for command and control systems, missile and space systems and test range and weapons support systems, engineering of communication networks, range instrumentation, tactical air control, and survivable communications.

NATIONAL AIRSPACE SYSTEM — We need people in MITRE's Washington, D. C. office to provide system engineering assistance to the Federal Aviation Agency for its new air traffic control system. MITRE's increasing responsibilities include broad level system design, computer program operational specification, equipment specification, configuration management, system integration, and system test planning. Experienced staff additions are needed in all areas.

COMPUTER PROGRAMMING TECHNIQUES — We need Systems Programmers with experience in the development and support of compilers, monitors, time sharing systems, man-machine languages, utility routines, software for on-line systems, display support and peripheral support programs, facility analyses, and simulation and modeling.

There are also openings in — The National Military Command System • Digital Systems Engineering • Sensor Systems and Techniques • Systems Analysis • Nuclear Weapons Effects Analysis • Tactical Systems.

If you have three or more years' experience and a degree, preferably advanced, in electronics, mathematics or physics, contact us. Write in confidence to Vice President — Technical Operations, The MITRE Corporation, Box 208G, Bedford, Massachusetts.

THE MITRE CORPORATION

An Equal Opportunity Employer

Pioneer in the design and development of command and control systems, MITRE was chartered in 1958 to serve only the United States Government. An independent nonprofit corporation, MITRE is technical advisor and systems engineer for the Electronic Systems Division of the Air Force Systems Command, and also serves the Department of Defense, and the Federal Aviation Agency.

AWARDS

AIR FORCE

$13,277,370—**Cutler-Hammer, Inc.,** Deer Park, N.Y., for airborne electronic reconnaissance systems spares.

$5,538,154—**Lockheed Aircraft Co.,** Sunnyvale, Calif., for continued production of *Agena* space boosters.

$1,443,398—**Raytheon Co.,** Waltham, Mass., for design, installation and operation of high-speed digital computers.

$1,291,363—**Garrett Corp.,** Phoenix, Ariz., for gas turbine generators.

$1,250,000—**Dow Chemical Co.,** Midland, Mich., supplemental funds for development and evaluation of advanced solid propellants.

$1,120,795—**General Electric Co.,** Syracuse, N.Y., for operation of the Pacific Missile Range.

$525,000—**Westinghouse Electric Corp.,** Aero Space Electrical Div., Lima, Ohio, for experimental evaluation and development of the power generator component of the SNAP-50/SPUR power system.

$285,000—**Radio Corp. of America,** Aerospace Systems Div., Burlington, Mass., for variable instruction computer.

$240,000—**Northrop Corp.,** Northrop Space Laboratories, Hawthorne, Calif., for electro-optical techniques for surveillance.

$150,000—**Radio Corp. of America,** Missile and Surface Radar Div., Moorestown, N.J., increase for BMEWS ECCM program.

$97,762—**United Aircraft Corp.,** United Technology Center, Sunnyvale, Calif., for development of a hypersolid ignition system.

$64,986—**Parametrics, Inc.,** Waltham, Mass., for atmospheric density measurement system.

$56,988—**Geo-Science, Inc.,** Alamogordo, N.M., for research directed toward observational studies of airglow.

$54,981—**Adcole Corp.,** Waltham, Mass., for research and development toward design, development, construction testing and installation of instrumentation for rocket probe ionospheric measurements.

$44,640—**Hughes Aircraft Co.,** Fullerton, Calif., for research on new and improved heat transfer fluids.

$40,588—**Aerojet-General Corp.,** Downey, Calif., for program for large solid boosters.

ARMY

$2,000,000—**Philco Corp.,** Philadelphia, for continued work on classified electronic equipment.

$1,250,800—**Radio Corp. of America,** Burlington, Mass., to produce test equipment for various missile systems.

$462,838—**Radio Corp. of America,** Missile and Surface Radar Div., Moorestown, N.J., increase for a classified program.

$57,708—**United Aircraft Corp.,** United Technology Center, Sunnyvale, Calif., for research program on combustion of solid propellants.

$24,605—**Astro-Space Laboratories, Inc.,** Huntsville, Ala., for engineering support to design and develop a seven-tube reusable rocket launcher for a folding fin aircraft rocket.

NAVY

$1,850,002—**Raytheon Co.,** Lexington, Mass., to produce hydraulic power units for the *Sparrow III* missile.

$1,796,000—**Control Data Corp.,** Minneapolis, to make targeting computers for *Polaris* missiles.

$1,793,000—**Sperry Rand Corp.,** Great Neck, N.Y., for research and development work on the control system for the *Talos* missile.

$1,493,075—**Lockheed Aircraft Co.,** Sunnyvale, Calif., for support equipment for the *Polaris* missile program.

$1,459,063—**Texas Instruments, Inc.,** Dallas, for radar set components.

$1,147,980—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for engineering work on the *Polaris* missile program.

$1,019,681—**Youngstown Welding Engineering Co.,** Youngstown, Ohio, for torpedo tube sets for nuclear powered submarines.

$917,000—**Maxson Electronics Corp.,** Great River, N.Y., for production of center sections for *Bullpup* missiles.

NASA

$674,000—**Varian Associates,** Palo Alto, Calif., for *Apollo* precision frequency sources.

$588,500—**North American Aviation, Inc.,** Rocketdyne Div., Canoga Park, Calif., for vehicle longitudinal stability analysis of J-2 engine.

$486,700—**Advance Technology Laboratory,** Mountain View, Calif., for design improvement program for *OGO* horizon sensor system.

$119,000—**Electronic Communications, Inc.,** St. Petersburg, Fla., to investigate and demonstrate feasibility and techniques for microminiaturizing the *Saturn/Apollo* flight control computer.

$94,000—**American Science and Engineering Inc.,** Cambridge, Mass., for reduction and analysis of data obtained from rocket flights.

$84,134—**Computer Usage Co., Inc.,** Washington, D.C. for computer program to determine gravitational field of the Moon.

$82,587—**Stanford Research Institute,** Menlo Park, Calif., for continued study on economic analysis of solid propulsion.

$70,176—**Technidyne Inc.,** West Chester, Pa., for a study on energy-dissipation systems for vehicular landings based on extrusion of metals.

$64,137—**Radio Corp. of America,** Missile and Surface Radar Div., Moorestown, N.J., for burst transmission of PCM data study.

$41,300—**Trans-Sonics, Inc.,** Burlington, Mass., for special temperature sensors to be used in conjunction with the Lunar Excursion Module program.

$40,800—**United Carbide Corp.,** Carbon Products Div., Parma, Ohio, for continuation of research on high temperature protective coating for refractory metals.

$36,850—**Data Control Systems Inc.,** Danbury, Conn., for a PCM decommutator.

INDUSTRY

$43,000,000—**Kollsman Instrument Corp.,** Elmhurst, N.Y., from **General Motors Corp.,** AC Spark Plug Div., Milwaukee, Wisc., for *Apollo* spacecraft optical navigation and associated ground support equipment.

$4,650,000—**Radio Corp. of America,** Communications Systems, Div., Camden, N.J., from **Western Union Telegraph Co.,** New York City, for equipment for the automatic digital network installed for the Defense Department.

$1,300,000—**Radio Corp. of America,** Electronic Components and Devices Div., Somerville, N.J., from **North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., for Darlington power circuits for *Minuteman*.

$300,000—**Dynamics Corp. of America,** New York City, from **Marconi Co., Ltd.,** Chelmsford, Essex, England, to build tropospheric scatter communications equipment.

$130,000—**Garrett Corp.,** AiResearch Manufacturing Div., Los Angeles, from **Douglas Aircraft Corp.,** Missiles and Space Div., Santa Monica, Calif., to evaluate and design a 10-kw Brayton cycle electric power generating system for NASA's Manned Orbital Research Laboratory.

$87,065—**Radio Corp. of America,** Missile and Surface Radar Div., Moorestown, N.J., from **Massachusetts Institute of Technology,** Cambridge, Mass., for the PRESS program.

$80,000—**Fairchild Hiller Corp.,** Stratos Div., Bay Shore, N.Y., from **General Electric Co.,** Re-Entry Systems Dept., Philadelphia, to design and fabricate heat transfer equipment for NASA's 1,000-lb. biosatellite.

$31,800—**Trans-Sonics, Inc.,** Burlington, Mass., from **Lear Siegler, Inc.,** Astronics Div., Santa Monica, Calif., for vertical velocity sensors.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Headquarters
Ballistics Systems Division
Norton Air Force Base, California 92409

Negotiations will be conducted with General Electric Co. for the continuation of the Mark 12 penetration aid subsystem research, development, testing and evaluation for the *Minuteman* program. This notice is for information only.

Bureau of Naval Weapons
Washington, D.C. 20360

A quotation will be solicited from Motorola, Inc., for Mk 12 Mod O guidance and control group for *Sidewinder IC*. Those firms interested in subcontracting opportunities should make direct contact with Motorola.

Office of Naval Research
Washington, D.C. 20360

Negotiations are to be conducted with the Astrophysics Research Corp. for further theoretical investigations of the excitation and propagation of fast ionosphere and magnetic disturbances. This notice is for information only; RFP not available.

Office of Naval Research
Washington, D.C. 20360

Negotiations are to be conducted with the American Institute of Biological Sciences for further research on biotelemetry. This notice is for information only; RFP not available.

U.S. Army Missile Command
Procurement and Production Directorate
Special Contract Division
Non-Systems Negotiation Branch
Redstone Arsenal, Alabama 35809

Negotiations will be conducted with Mechanical Technology Inc. for a research program in support of a gas bearing, pneumatic pickoff gyro design and development program. Those interested in subcontracting opportunities should make direct contact with the above company.

U.S. Army Missile Command
Redstone Arsenal, Alabama
AMSMI-IXDA

A contract for motor evaluation of advanced concepts for guided missiles will be negotiated with Rohm and Haas Co. Those interested in subcontracting opportunities should make contact directly with the above listed firm.

National Aeronautics and Space Administration
Flight Research Center
P.O. Box 273
Edwards AFB, California 93523

Negotiations will be conducted with Spacelabs, Inc., for research and theoretical studies of data analysis techniques applicable to flight biodata and for formulation of a program for automatic processing of bulk biodata. This notice is for information only; RFP not available.

National Aeronautics and Space Administration
Western Operations Office
150 Pico Blvd.
Santa Monica, California 90406

A contract is being negotiated with North American Aviation, Inc., for a continuation of chamber technology for space storable propellants. This notice is for information only; RFP not available.

AIRBORNE RADAR SYSTEMS ENGINEERS

Our Aeronautical Systems Division has several openings for Airborne Radar Systems Engineers who are familiar with fire control systems and the associated AGE and maintenance testing, and who have experience defining test equipment requirements, or are familiar with development/integration testing.

The assignments will involve the analysis and definition of customer requirements related to the maintenance and checkout of prime aero equipment, the functional design of AGE and/or the supervision of laboratory test activities. An accredited degree in E.E. and a minimum of three years of applicable, professional experience are required.

U.S. CITIZENSHIP IS REQUIRED.

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Head of Employment
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Culver City 87, California

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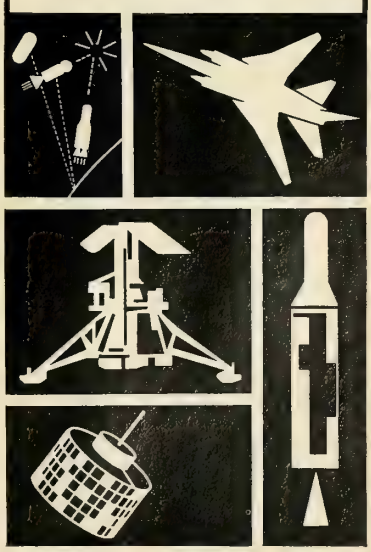
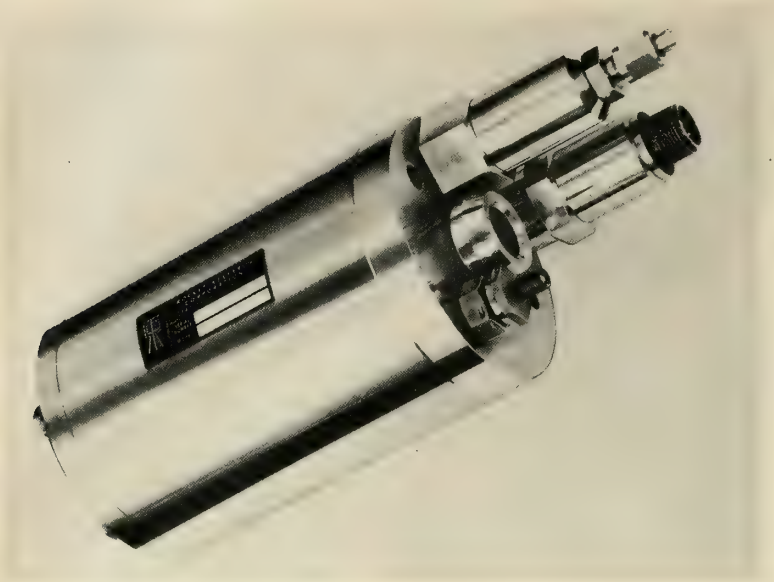




New Product of the Week:

Bootstrap Gas Generator

A hydrazine gas generator that uses the "Bootstrap" principle has been introduced by Rocket Research Corp. The self-pressurizing device provides low-pressure storage and eliminates the requirement for a separate system to maintain fuel pressure, the firm says.

In operation, liquid hydrazine fuel is passed through the #405 catalyst from Shell Development Co. to produce gases with no solid contaminants. Gases are delivered at pressures up to 3,000 psia. Output gas temperature can be varied from 2,200° to 60°F. A fuel freezing below −65°F can be supplied.

The self-contained unit is capable of on-off, continuous or proportional operation. It delivers 37 gas hp, measures 4 in. in diameter and 10 in. long and contains 0.75 lbs. of fuel. Initiation is achieved by actuating a solenoid valve; the unit can be supplied with squib or explosive valve initiation.

Circle No. 151 on Subscriber Service Card

Electronic Counter/Timer

Monsanto Co.'s Inorganic Chemicals Div. is marketing an electronic counter/timer with a frequency range of 0 to 20 MHz—ac- or dc-coupled.

The Model 1000 offers a time interval of 10^{-7} to 10^{7} seconds and resolution of 50 nanosecs. Input sensitivity is 100m millivolts; input impedance is 1 megohm 40 pf. The unit has a display of seven in-line digits and coded output of 1-2-4-8 BCD. Accuracy is ±1 count ± osc. stability. Stability after one-hour warmup is 1 part in 10^{7}.

Circle No. 152 on Subscriber Service Card

Charge Amplifier

A miniature, airborne charge amplifier for use with long cable is available from Gulton Industries, Inc.

The Model FT-3414 is 100% humidity-proof and has an essentially flat frequency response with use of up to 500 ft. of RG-59 cable. The unit has a frequency response of 5 to 1,750 cps and full range output of 5v, peak-to-peak. RFI rejection exceeds requirements of MIL-1-26600. Power requirement is 40 ma at 28 ±4v dc. The device has an operating temperature range of −40° to 185°F, will withstand shocks up to 50 g's, and vibration levels up to 35 g's peak from 30 cps to 2 kc.

Circle No. 153 on Subscriber Service Card

Liquid Q Switch

A passive liquid Q switch designed to obtain giant pulses from ruby lasers is being marketed by Beckman & Whitley, Inc.

Liquid used is a treated solution of cryptocyanine, which is self-healing. The self-synchronizing switch eliminates need for rotation, prepumping or application of external fields, developers say.

Four models of the device are available with absorption values from 40% to 70%. The unit's optically flat windows are 1 in. in diameter and are opaque to radiation wavelengths smaller than 6,000 Angstroms but transparent at 6,940 Å. Liquid path is approximately ¼ in.; overall thickness of the liquid plus the windows is approximately ½ in.

Circle No. 154 on Subscriber Service Card

Adaptable Evaporator

A new design concept in equipment that allows the basic vacuum evaporator to become a zone refiner, a shadowing apparatus for electron microscopy, a field ion microscope, a field emission microscope, an arc furnace, a vapor depositor or a number of other devices requiring vacuum has been announced by Materials Research Corp.

The V4-EVD system is basically an electron beam vapor deposition unit. But modularization provides the laboratory of small volume production groups with a single unit which can be adapted to many tasks requiring vacuum. About 50 different vacuum feed-throughs are available for use with the system. All modules, components and feed-throughs are common in that they have been designed for use with MRC's vacuum collars.

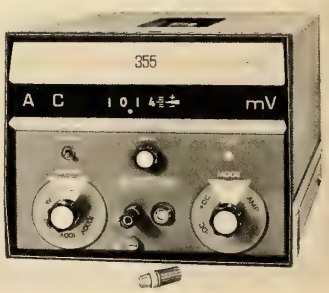
The systems are available for various vacuum levels. The stock units are available with 4-in. and 6-in. diffusion pump systems, with 12-in. and 18-in. vacuum collars and bell jars. Higher vacuum, bakeable systems with ion pumps and steel bell jars are also available.

Circle No. 155 on Subscriber Service Card

DC-AC Digital Voltmeter

Ballantine Laboratories is marketing a dc-ac digital voltmeter, the Model 355.

The instrument measures d-c voltages from 0 to 1,000 in five decade



ranges and a-c voltages from 0 to 1,000 in six decade ranges. The ac may be any frequency from 30 Hertz to 250 kilohertz. Accuracy is 0.25% f.s. for dc and ac voltages up to 500. Power requirement is 52 watts from a source of 115/230v at 50 to 420 Hertz.

Circle No. 156 on Subscriber Service Card

New Cubic systems will help pinpoint battlefield targets with accuracy never before achieved!

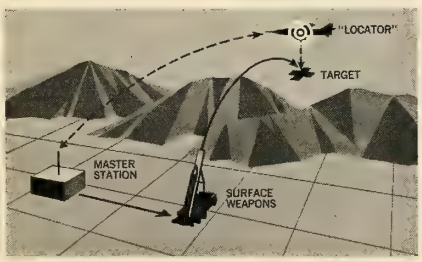
Deadly accurate electronic systems from Cubic Corporation will help eliminate target location guesswork. They answer the long-standing need for a means of "locating the locator" in targeting.

In today's highly fluid battlefield environment, it is not enough to know only where the target is relative to a "locator" (man, aircraft, drone, helicopter). What must be known is the precise position of the "locator" when it sees the target. Cubic's targeting systems accomplish this instantaneously and accurately.

System concept...

Cubic systems continuously fix a "locator's" position at the instant a target is seen. These positionings become part of a flexible trilateration network composed of ground-based and airborne receiver-transmitters. To obtain line-of-sight accuracies over the horizon, airborne relays are used.

As a result of these Cubic systems, multiple weapons at remote locations can be fired at the right targets quickly.



Electronic targeting operation: Existing airborne or ground-based "locators" can already spot targets. New Cubic systems locate these "locators" with speed and pinpoint accuracy!

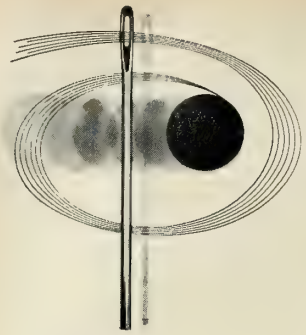
Proven capability...

Development of advanced targeting systems stems from Cubic's industry-leading experience in the field of electronic distance measurement. The U.S. Army's SECOR satellite surveyor and the key element of the U.S. Air Force aerial photomapping system are both recent Cubic achievements.

Electronic battlefield targeting will prove increasingly important in defense and "brushfire" warfare control. For information, write: Chief Scientist, Cubic Corporation, Dept. D-157, San Diego, Calif. 92123.

CUBIC
CORPORATION
SAN DIEGO, CALIFORNIA 92123
SYSTEMS DIVISION

Circle No. 25 on Subscriber Service Card



LOOK AT LOCKHEED ...IN GUIDANCE

Research and development in the technology of Guidance is not confined to any one discipline. Broad interests and exceptional capabilities are required, as typified by the following:

GUIDANCE—Ability to formulate guidance laws for missile and spacecraft missions. Familiarity with digital simulation techniques and calculus of variations or methods of steepest descent.

VIBRATION/ACOUSTICS — Develop environment criteria for structural designs from ground and flight data. Advance the state-of-the-art in vibration and acoustical prediction methods.

METEOROLOGY—Perform fundamental studies in turbulence, ground winds, and other natural environments. Understand the latest instrumentation, data acquisition and data analysis techniques.

FLIGHT MECHANICS — Analyze guidance accuracy from tracking data. Apply analog and digital simulation techniques to general vehicle performance studies. Generate mathematical models of dynamic systems.

SCIENTIFIC PROGRAMMING— Program and operate Analog or Hybrid Computers and Differential Analyzers. Define models for simulation of aerospace guidance and control problems and analyze results.

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LOCKHEED
MISSILES & SPACE COMPANY
A GROUP DIVISION OF LOCKHEED AIRCRAFT CORPORATION

An equal opportunity employer

names in the news

NOLAN

DORMEYER

GRUNER

GILRUTH

Richard R. Nolan: Promoted to senior vice president, manufacturing and administration, of Northrop Corp. One of the first employees of Northrop, he has been corporate vice president since January, 1965.

Ernest W. Dormeyer, Jr.: Elected president of Protective Closures Co., Inc. He was formerly executive vice president.

Heinz Gruner: Elected second vice president of the American Society of Photogrammetry. He is senior scientist at Bausch and Lomb Inc.

Dr. Robert R. Gilruth: Named keynote speaker for the Third Annual Aerospace Technical Conference of the Institute of Electrical and Electronics Engineers in June. He is director of NASA's Manned Spacecraft Center.

David A. Shepard and Dr. Horton Guyford Stever: Elected to the board of trustees of the System Development Corp. Shepard is an executive vice president and a director of Standard Oil Co. (N.J.), and Stever is president of Carnegie Institute of Technology, Pittsburgh, and chairman of the Air Force Scientific Advisory Board.

Roy Calvin: Elected vice president-public relations of the Martin Co. He was formerly public relations director.

D. Richard French: Elected vice president of Aluminium Limited. Also elected vice presidents were **John F. Haertlein** and **John A. McKinley.**

Dr. James N. Waggoner: Elected first vice president of the Aerospace Medical Assn. for the forthcoming year. He is medical director for the Garrett Corp.

Aaron Bloom: Became president of Aerospace Industrial Life Sciences Assn. at the recently held meetings of the association in New York City. He is president of Sierra Engineering Co.

Rocco Fiaschetti: Re-elected president of the American Society for Quality Control. He is special assistant to the director of quality control at North American Aviation's Space and Information Systems Div.

Donn L. Williams: Returned to the Autonetics Div. of North American Aviation, Inc., as assistant to the division president. He had been with Tamar Electronics. He will be acting director of program development.

L. C. Holmes: Named chairman of the Awards Board of the Institute of Electrical and Electronics Engineers. He is also a national director of the organization.

Patrick W. Zilliacus: Elected executive vice president of Jefferson Electric Co.

John G. Brooks: Newly installed as a member of the board of the Chamber of Commerce of the United States, the first representative of the electronics industry to be elected to that body. He is board chairman and president of Lear Siegler, Inc.

Richard H. Goodwin: Appointed manager of operations control for the Communications Systems Div. of Radio Corp. of America's Defense Electronic Products.

Warren B. Riley: Elected vice president-corporate planning and marketing of Federal-Mogul Corp. He was formerly with The Bendix Corp.

Dr. Wernher Von Braun: To receive an award for outstanding contributions to the national program for space exploration in the interests of scientific knowledge at the Space Electronics Symposium next week in Los Angeles. **Gen. Bernard A. Schriever,** Air Force Systems Command's commander, will receive an award for outstanding contributions in space exploration in the interests of national defense. The symposium is sponsored by the Aerospace Electrical Society and the American Astronautical Society.

Robert J. Marmorstone: Elected president of Datex Corp., a subsidiary of Giannini Controls Corp.

Neil Gorchow: Appointed director, systems programming, of Sperry Rand Corp.'s UNIVAC Data Processing Div.

Robert B. Pirie: Appointed chairman of the board of Aerojet-General Shipyards.

W. J. Jackson: Elected controller of Cook Electric Co. The position was recently made an official company office, which it had not been previously.

Dr. Robert Swern Wiseman: Named to head the recently-created Combat Surveillance-Target Acquisition Laboratory of the U.S. Army Electronics Command.

—when and where—

MAY

24th Annual Conference of the Society of Aeronautical Weight Engineers, Brown Palace Hotel, Denver, Colo., May 17-19.

International Conference on the Application of Computing Methods to Reactor Problems, sponsored by the American Nuclear Society, Argonne National Laboratory and European Nuclear Energy Div., Argonne, Ill., May 17-19.

Design Engineering Show, sponsored by the American Society of Mechanical Engineers, New York Coliseum and Americana Hotel, New York City, May 17-20.

International Conference on Components and Materials Used in Electronics Engineering, sponsored by the Institution of Electronic and Radio Engineers and Institute of Electrical and Electronics Engineers, London, May 17-21.

Annual Conference of the Society of Photographic Scientists and Engineers, Sheraton-Cleveland Hotel, Cleveland, May 17-21.

International Telemetering Conference, sponsored by the International Foundation for Telemetering, Washington, D.C., May 18-20.

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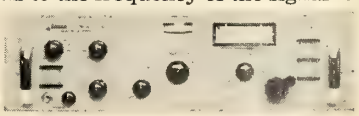

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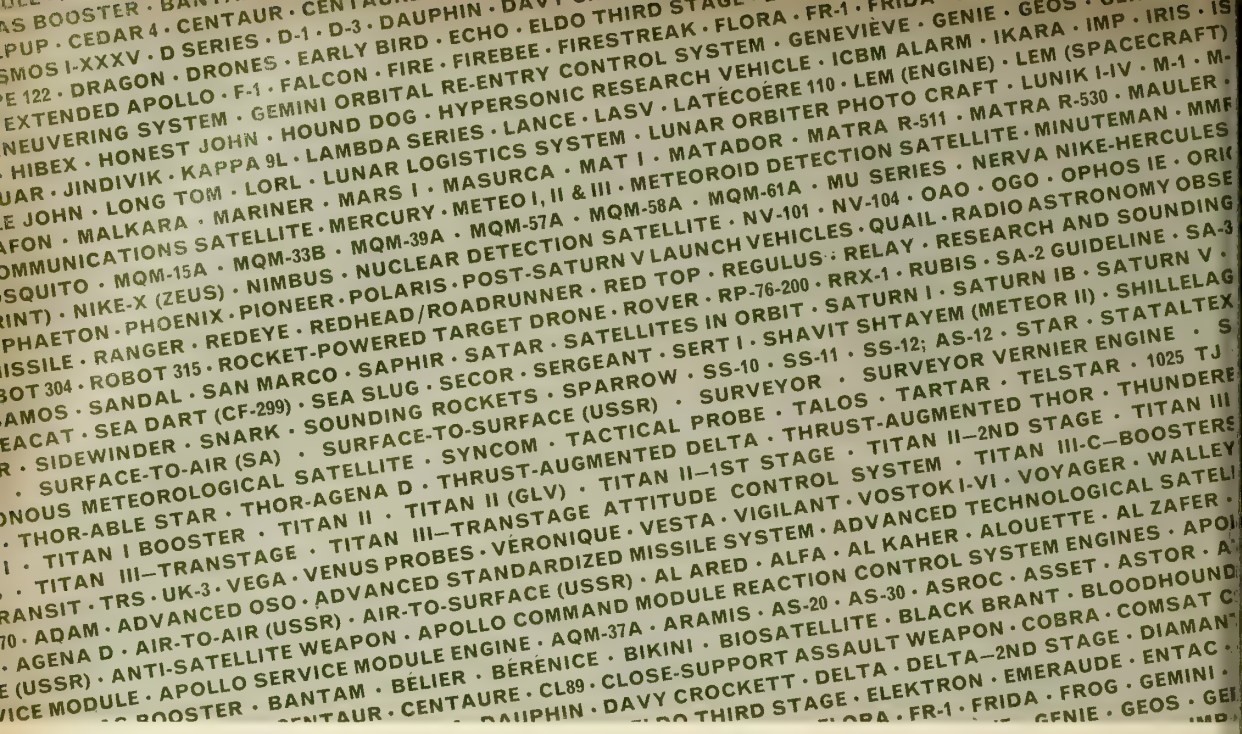
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Soviet Strength

THE SOVIET UNION, with its May 9 display of missile and space might, has dealt a major blow to the complacency of those persons in the United States who consistently have underestimated the competence of the Russians in these fields.

The appearance of Soviet solid-fuel missiles of a type similar to the U.S. *Minuteman* ICBM indicates that the Soviets finally have overcome the chemical roadblock which until now has made possible the U.S. lead in solids. We predicted just such a development on this page last January (M/R, Jan. 11, p. 46).

The credit rests with former Soviet premier Nikita Khrushchev. He did not fail to grasp the fact that the early unwieldy liquid-fueled Russian ICBM's were militarily and geopolitically unsatisfactory. The intensive Russian effort to grasp the technology of solids now has paid off.

In a film which the Moscow correspondent of the *New York Times* estimated to be at least three years old, the Soviets also displayed launchings from an underground silo. The combination of these events suggests the Soviets now are in a position to rapidly close the missile gap with the United States to the point where it is of no consequence in military calculations. The gap was a deliberate gamble on the part of the Soviet Union during development of the solid ICBM.

This is not entirely a gloomy turn of events for the U.S. Solid-fuel missiles and underground silos make it possible for the Soviets now to assume a second-strike posture in military confrontations with the West.

The Administration's display of confidence in recent months in the less intransigent attitude of the Soviet Union on the world scene, may, in fact, stem from early knowledge of these developments. Construction of underground silos would be difficult to hide from the high-resolution cameras of U.S. reconnaissance satellites.

We should not forget, however, that an ominous interpretation also can be put on such activities. Underground silos make it possible to conceal first-strike preparation, something that was not possible with liquid-fueled above-ground missiles. The damage-limiting nature of silos also removes from a first-strike position the necessity of getting all missiles off in salvo.

The Soviets also displayed an intermediate-range missile unmatched in the Western arsenal. Mounted on a tracked carrier, this very mobile weapon was described as having a range of 1,100 miles. It, too, was solid-fueled.

The nearest comparable U.S. missile is the *Pershing,* with only half the range. It appears that while the U.S. has been discussing the *Mobile Medium-Range Ballistic Missile* (*MMRBM*), the Soviet Union has been building it.

In the film release, the Russians for the first time showed their anti-missile missile in action. One sequence was of intercept of an ICBM.

Again, it must be remembered that the film probably was three years old. The Russian Defense Minister announced in October, 1962, that the Soviets had solved the anti-ICBM problem and the Russian lead in the field was officially acknowledged in the U.S. about the same time.

Undoubtedly, the effort on anti-ICBM's is much further along at this time. There is a significant side-effect to this work also. The chances are exceedingly good that Soviet ICBM's are quite sophisticated as to penetration aids. Most certainly, knowledge from the anti-missile program would have been used in this fashion, just as the U.S. has made similar use of information from the *Nike-X* program.

Therefore, the requirement imposed on *Nike-X* becomes even more severe and must be taken into account in the decision as to whether and when it should go into production.

The Soviets also displayed a new radio-guided anti-tank missile which is of interest in view of U.S. difficulties in developing an entirely satisfactory missile in this field.

Films of submarine launchings of *Polaris*-type missiles also were shown, a clear warning that the Navy's ASW burden can be expected to increase.

There are two comments which might be made on the display of Soviet missile might. First, it indicates a growing confidence in the capability of their weapons—since they are unlikely to display weapons of dubious quality. Second, going along with the new second-strike posture, it indicates an increased Russian belief in the value of deterrence. As U.S. Secretary of Defense McNamara has pointed out, a deterrent is of no value unless it is credible to the enemy. Therefore, it must be displayed. Despite some interpretations of the Russian show as warlike, this position on deterrence surely is to be welcomed, since deterrence is a defensive attitude.

THE INCREASING Soviet confidence also is indicated in the space field. The Soviets let it be known more than a month in advance that their next space spectacular could be expected on May 9 (M/R, April 5, p. 7). The launch of *Lunik V* obviously was right on schedule. The acknowledgement after launch but in advance of impact that its goal was a lunar soft-landing also is a more realistic approach to space developments than previously shown.

This shift toward a franker attitude is supported by the open admission of the *Zond II* Mars probe failure by Soviet scientists attending the Space Exploration Symposium in Chicago on May 4.

At the same time, the Russians released more information on the Soviet space program at the Chicago meeting than heretofore.

All of this points toward greater maturity in both Soviet missile programs and Soviet space programs. The competition therefore is far keener than many persons in the U.S. have been willing to admit.

The conclusion is clear. The U.S. cannot afford to let down or it will be far outdistanced in areas which will continue to be vital to its national security and well-being for many, many years.

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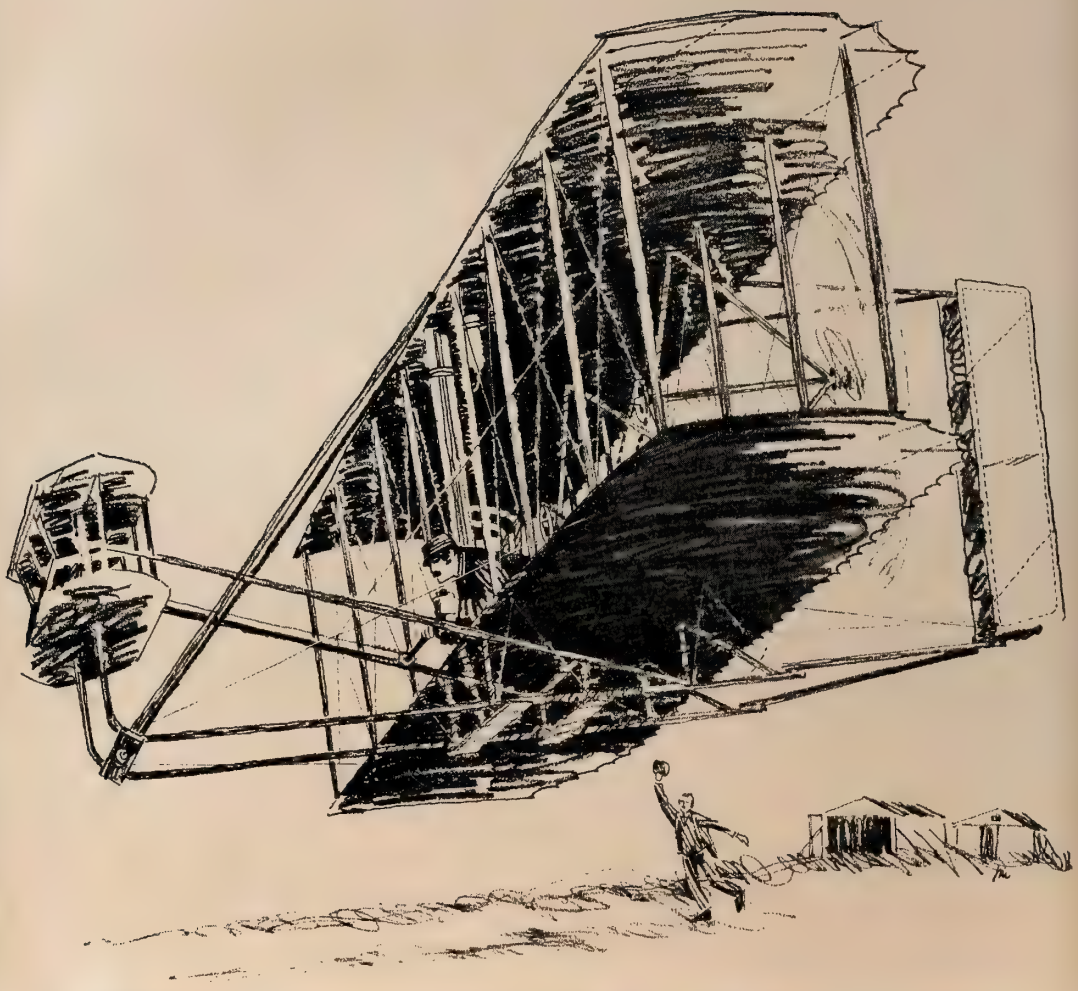

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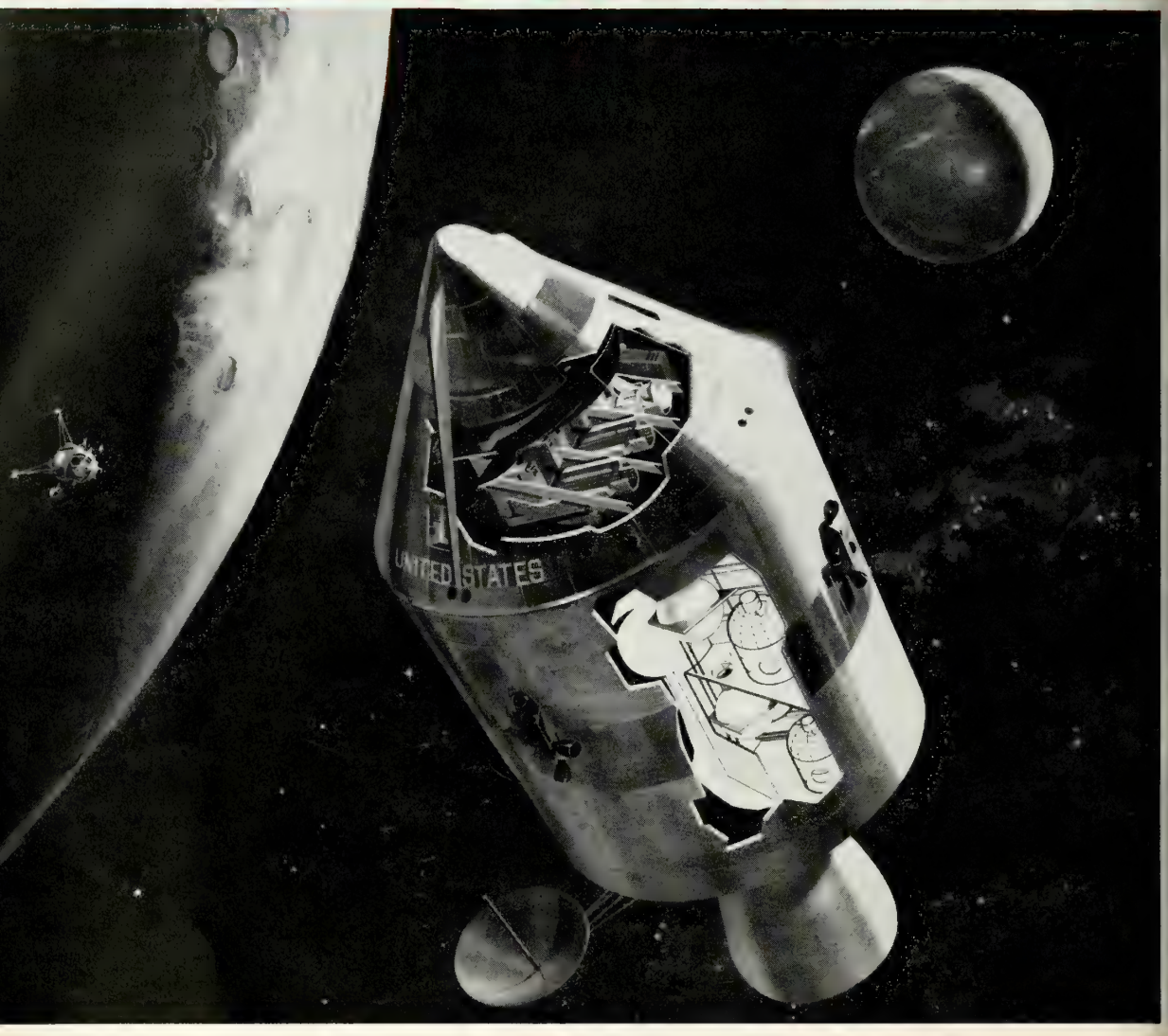

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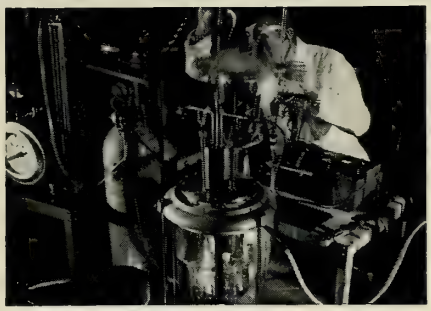

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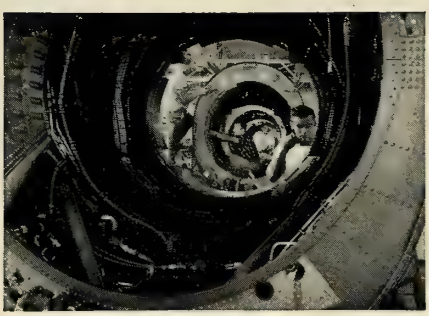

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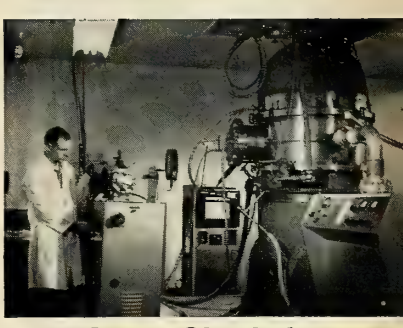

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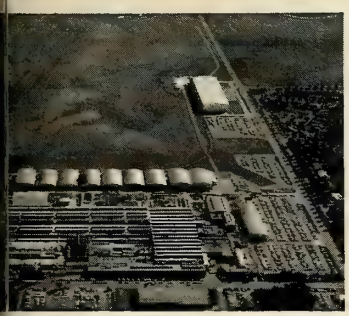

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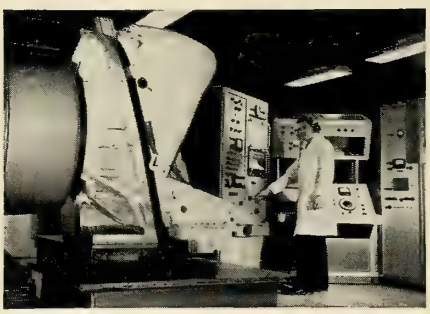

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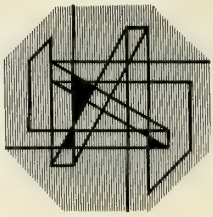

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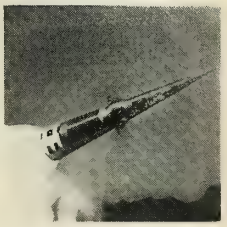

THE COVER

First photo released by the Army of the first launch of the Sprint anti-missile missile, which took place March 26 at White Sands Missile Range, N.M. An above-ground launcher was used for this test, although the tactical concept involves a "pop-up" from an underground silo.

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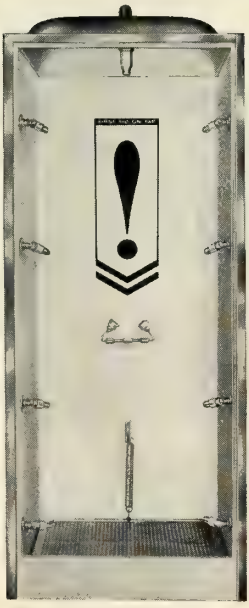
A Quick Step to "First Aid on Tap!"



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letters

Bologna and Hot Water

To the Editor:

I am not quite used to writing letters to the editor. However, I must comment on your April 5 editorial ("Fun and Games") concerning the "bologna sandwich" which the astronauts (Gus Grissom) partially ate on the *GT-3* flight.

The first time I read of the sandwich incident, I too believed that the astronauts were above reproach, and that a "silly" thing like this deserved no criticism; it seemed as if they were making "a mountain out of a molehill." Having average interest in our world of today, space flights in particular, this all seemed rather immaterial to me, and many of my acquaintances alike. I'm afraid I do realize now, however, how a little incident could possibly "snowball" into something much bigger and more important. I plan on showing these people your article; I'm sure they'll also take on a different viewpoint of this incident.

Thank you for clearing things up for me, and I hope that not too many people join together, putting yourself and Mr. Hines in that "pot of hot water."

Jeri L. Beck
Inglewood, Calif.

NASA Administrator James E. Webb, commenting on the incident during recently released Congressional testimony, said: "I do not agree that you can tolerate this kind of deviation from what is clearly the purpose and requirement for success on these flights. These are outstanding young men, and they are under a strain, but this is the United States of America's space program, and as a matter of policy we are not going to permit individuals to superimpose their judgment as to what is going to be taken on these flights."—Ed.

Velikovsky Revisited

To the Editor:

The March 22 M/R carried an interesting editorial, "This High Man," in honor of Dr. Robert H. Goddard, "the father of modern rockets, missiles, and astronautics." It is good to learn more about the life of this great man.

In your editorial you mention that "Goddard's dream was the object of derision 39 years ago" and you pose the questions "Who, we must wonder, is the dreamer today who is being ignored? Where is he? What is he working on that will change the world so vastly 39 years from now?"

I suggest that a most likely candidate is Dr. Immanuel Velikovsky, the author of "Worlds in Collision" (1950), "Ages in Chaos, Vol. I" (1952), "Earth in Upheaval" (1955), and "Oedipus and Akhnaton" (1960).

As you may know, Dr. Velikovsky and his ideas have been the subject of much controversy over the past 15 years as a result of the cataclysmic views he holds as set forth in his books.

Unfavorable criticism by reviewers who had only cursorily read his books has caused scientists to ignore or rebuke his work.

However, because some of the discoveries made recently in the course of the space program bear out the predictions Velikovsky made in his writings, there are signs that scientists are beginning to pay some heed to Velikovsky's ideas.

I believe that it is high time that a concerted effort be made by scientists in many fields to check Dr. Velikovsky's theories. This could best be carried out as a part of the space and oceanographic programs and will, when accomplished, do much to advance both programs.

I further believe that if American scientists do not soon engage in this work, Russian scientists will—thereby "scooping" the U.S. once again.

That there is keen interest among student scientists who have been fortunate enough to hear Dr. Velikovsky personally express his views is evidenced by the formation of study groups known as "Cosmos and Chronos Discussion Groups." These meet regularly to discuss and examine Dr. Velikovsky's theories. Among those colleges and universities which have heard him lecture are Princeton, Brown, University of Pittsburgh, Carnegie Institute of Technology, Oberlin, Kent, and St. Vincent's College.

In some colleges, students in certain courses have as required reading one or more of his books.

F. Thomas Lowrey
Pittsburgh, Pa.

Parafoil Potential

To the Editor:

We appreciate very much your timely article on the Jalbert Multicell Parafoil (M/R, May 10, p. 38). Yours is the first major publication to discover and acknowledge the operational potential of the Parafoil.

This entirely new concept in aerial devices can be used in tethered flight for suspending radar calibrating devices, ships' antennas, instruments for meteorological observations, etc. Additionally, it can be easily adapted for guided recovery of air-dropped cargo, rocket boosters and space capsules.

Please note that the picture of the Parafoil on p. 39, depicting tethered flight, was taken immediately after launch, during the climbing phase. Actually, the Parafoil is rigged to fly in tethered flight at an angle of 70-80 deg overhead. It differs from a kite and a parachute in that they are both drag devices whereas the Parafoil, which is non-rigid and constructed of tough, lightweight fabric, performs exactly as an aircraft wing, by creating lifting forces over its airfoil surface.

Walter G. Winslow
President
Space Recovery Research Center, Inc.
Boca Raton, Fla.

Engineers and Scientists are invited to inquire about the professional openings available immediately with General Electric on the Apollo Program

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Electrical Engineer-Reliability Analysis-BSEE (Also for Cocoa Beach, Fla.) — Design, test or analysis of electrical systems, with at least two years in failure mode and effects analysis, determination of criticality numbers, or development of math models. Coordinate analytical effort with design and test personnel.

HOUSTON, TEXAS

Experience required in the following areas:

Project Engineers Parts & Material Qualification BSEE or BS Physics — Generating and updating parts and materials qualification status lists from test and analytical results generated by contractors and vendors. Responsibility for establishing and maintaining management and communications systems. Other area openings for parts and materials specifications and procedures; failure reporting. Each requires 5-10 years experience in specific field of specialty.

Engineer, Failure Data (or Analysis) BA/BS, Math, Physics or Engr'g. — Analyze failure and use data for parts and materials. Perform assessments of parts and materials reliability. 5-10 years experience in defense industry parts and materials qualification testing and analysis. Familiarity with mathematics of test data report handling (plot trends).

Engineer-Cryogenics Fuel Cell BSME/ChE. — 3 to 5 years experience in work involving Cryogenics, Fuel Cells and associated systems. This should include systems design and analysis. Provide technical assessment of design of spacecraft systems emphasizing reliability.

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Engineer-Operational Analysis BSME, AE, CE, IE — Develop systems management procedures and system analysis of launch facilities and equipment. Minimum 2-3 years experience preferably in similar aerospace program. Must deal with customers, know and be able to document all functions, authorities, responsibilities of organization and information flow. Require familiarity with AFSC 375 series system and government documents.

Engineer/Specialist Quality Control Tech. degree preferred — Experienced in the Quality Control field with emphasis on writing quality procedures, developing test and inspection flow charts, writing test procedures and designing test equipment.

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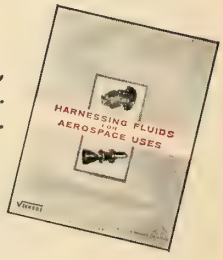
For more of the Vickers story, write for Bulletin A-5283A. Vickers Incorporated, P.O. Box 302, Troy, Michigan.



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The Countdown

WASHINGTON

Report Due on 260-in. Case Failure

NASA expects to have a final report by the end of this month on cause of the failure of a Thiokol Chemical Corp. 260-in. solid motor case during a structural test. Preliminary data suggest there were two flaws in weld areas, but earlier X-ray tests indicated they were not present when the cases were made. Officials are trying to decide whether the flaws were caused by the hydrostatic test or were already present. One prime suspect is the sub-arc welding method used by Newport News Shipbuilding Co., subcontractor to Thiokol. The tungsten inert gas method used by Aerojet-General, which is also building two half-length cases under a parallel program, apparently turns out stronger cases. The hold on development of Thiokol's second case is being continued by NASA until at least the end of May. Aerojet still plans to fire its first case in September, well ahead of Thiokol. But NASA hopes to continue the Thiokol effort.

OTS Design RFP Is Imminent

Marshall Space Flight Center is expected to issue an RFP this week on preliminary design of the *Optical Technology Satellite*. Incremental funding will be used in the project. Overall direction is in the Office of Advanced Research & Technology.

Breakdown of Added SE Asia Funding

Aircraft, missiles and ordnance for the Army, Navy and Air Force will be purchased to the tune of $368.8 million —more than half of the supplemental defense appropriation for support of military action in Southeast Asia, mainly Viet Nam. Long-leadtime items for three types of aircraft are expected to cost $54.7 million—$8.7 million for the Army, $32 million for the Navy and $14 million for the Air Force. Additional operation and maintenance funds totaling $152.6 million will yield $46.6 million for Army, $56.2 million Navy and $49.8 million for Air Force.

Senators Unhappy with NASA Forecast

Senate Space Committee sharply rapped NASA's recent "Summary Report Future Programs Task Group," setting forth plans for future manned space projects, as being obsolete and lacking in a number of points of information. The committee is giving serious consideration to holding open hearings this summer or fall to get some firm decisions on post-*Apollo* programs. It also said it expects to get a detailed briefing on the *Manned Orbiting Laboratory* as soon as a definite program is decided upon, "probably in mid-July."

ERC Picks Up Contracting Momentum

NASA's Electronics Research Center expects to award another 22 study contracts in various research areas before June 30. It has already let eight contracts and is in the single-source negotiation phase for four others. ERC also issued RFP's for equipment for two laboratories scheduled to be built at its temporary Cambridge, Mass., location.

Lunik Cloud of Dust Discounted

Reports that Russia's *Lunik V* Moon probe raised a huge cloud of dust when it impacted are regarded very skeptically by members of the *Ranger* photo-evaluation team, who are especially dubious about a report from an East German tracking station that the alleged cloud was 145 mi. long and 50 mi. wide. "That amount of material would weigh quite a few tons," one expert commented. "An impact wouldn't create that, and it seems unlikely that that much would be stirred up by retrorockets."

INDUSTRY

Fuel Cell Operates for 1,300 Hours

First of 10 2-kw-output hydrogen-oxygen fuel cells being developed for NASA by Allis-Chalmers has been operated successfully for more than 1,300 hours—equal to more than nine Earth-Moon round trips. John Platner, A-C's NASA fuel-cell program manager, told the 19th Annual Power Sources Conference in Atlantic City that the test unit was cycled from 800-2,300 watts output at 28 V and produced 2½-3 gals. of pure water per day. (A capillary-asbestos membrane system is used for integral distillation to assure purity.) Platner asserted that the test program has now proven suitability of the 2-kw system for extended manned space missions.

X-15/XB-70A Mating Urged as Aerospace Plane

North American Aviation says its studies show that the *X-15* and XB-70A could be modified and mated to form a two-stage *Aerospace Plane*-type vehicle for research purposes. The firm has proposed the plan informally to NASA. Study dates back to a proposal several years ago to carry an *X-15* piggyback on an XB-70 to provide a vehicle for a *Dyna-Soar*-type research project. If an *X-15* was used, it would have a delta-wing configuration. However, NAA studies have also considered using the XB-70 to carry lifting re-entry bodies or orbital vehicles for manned spaceflight investigation. The No. 2 XB-70 is slated for rollout Saturday.

McDonnell To Prepare Used Gemini for AF

McDonnell Aircraft Corp. will refurbish the *Gemini 2* spacecraft for use in one of the two unmanned flight tests planned in the Air Force *MOL* program. The firm will receive $5 million for the work. Spacecraft is scheduled for delivery to the Air Force in July, 1966.

INTERNATIONAL

British Show off Seacat at Pt. Mugu

British Royal Navy's guided missile destroyer HMS Kent demonstrated the *Seacat* missile for U.S. Navy observers at Pt. Mugu, Calif., May 19. Pacific Missile Range provided range support and an aviation rescue boat as a surface target. The Kent provided its own KD-2R target drone for the ship-to-air demonstration. High-ranking U.S. Navy officers attended.

Japanese May Build Own Air-to-Air Missile

Possibility of producing a Japanese-designed air-to-air missile is being considered by the Japanese Defense Agency. Weapon would replace the U.S.-built *Sidewinder* now deployed on F-104J fighters, the mainstay of Japanese air defense. The effort, if authorized, would be part of the nation's third five-year defense build-up program, starting in FY 1967.

The Missile/Space Week

Shots of the Week

The *Apollo* launch escape system passed an unintentional acid test May 19 when its *Little Joe II* booster flew apart at 15,000 ft. The accident occurred 25 seconds after a launch that was to have tested the escape system's abort capabilities at 112,000 ft.

First-stage ignition of the booster was normal, but a problem in the autopilot apparently caused it to roll at a rate 90% greater than expected. The strain imposed by the excessive roll rate destroyed the vehicle. However, when the booster came apart, ". . . the abort system for the *Apollo* spacecraft worked perfectly," in the words of Manned Spacecraft Center Apollo project chief Joseph Shea.

Astronaut Richard Gordon, who witnessed the display, said, "I feel confident astronauts would have been safe."

- Shipboard firings were begun May 10 off Point Mugu, Calif., to evaluate *Seaspar*, a surface-to-air version of the *Sparrow III* air-to-air missile.
- The first firing of a production model of the Army's *Roadrunner* target missile May 17 resulted in a perfect test at speeds greater than Mach 1 and at a programmed altitude of 6,200 ft. The *Roadrunner*, the low-level version of the *Redhead Roadrunner*, used a Marquardt 16.5-in. ramjet engine during the cruise portion of the flight. The engine operated supersonically in the test, but can also power the target at subsonic speeds. Marquardt is developing a 19-in. ramjet to extend the missile's performance. The *Roadrunner* is designed and built by North American Aviation's Columbus Div. and uses a Rocketdyne-McGregor solid boost motor prior to ramjet initiation.
- The Air Force on May 18 used a *Thor-Agena* launch vehicle to boost a satellite of undisclosed type from Vandenberg AFB, Calif.
- NASA used a Javelin rocket May 19 to loft a "mother-daughter" payload for making ionospheric measurements from Wallops Island, Va.

New Detection System Told

Ryukyu Air Defense System (RADS) is the designation for a new airspace surveillance and weapons control system to be installed in the Pacific Island chain, which includes Okinawa.

The Air Force Systems Command's Electronic Systems Div. has the direction of the project through its 418L system program office.

The new system is similar to an air defense system ESD recently completed in West Germany. Like its European counterpart, RADS will detect and identify airspace intruders in its area and direct aircraft or missile interception.

Industry has been solicited for letters of interest in the project and interested firms were briefed by ESD at a bidders' briefing May 3 and 4. A firm contract is expected by the end of this year.

The manual system now in use in the Ryukyus area is to be modernized, using primarily off-the-shelf engineering and electronics components and techniques.

ABC May Launch Satellite

The American Broadcasting Co. is looking into plans to launch its own domestic communications satellite to relay television programs to its affiliated stations.

The company met with the Communications Satellite Corp. last week to discuss the possibility of launching a synchronous satellite that could serve the entire United States, including Hawaii.

Reportedly, ABC has retained Hughes Aircraft Co., developers of Comsat's *Early Bird* satellite, and TRW Space Technology Laboratories as technical consultants for the program.

Comsat officials expressed a willingness to cooperate with the ABC project, but defended its position as the "chosen instrument" of Congress in the area of commercial communications satellites.

According to Leonard H. Goldenson, ABC president, the Communications Satellite Act of 1962—which created Comsat—does not preclude the creation of additional communications satellite systems.

Solar Explorer Planned

NASA and the Naval Research Laboratory plan to launch a *Solar Explorer* satellite to obtain data from solar X-ray emissions sometime during the second half of this year.

The launch from Wallops Island will come during the final portion of the 1964-65 International Quiet Sun Year.

The 125-lb. satellite, developed by NRL, consists of two 24-in. hemispheres. These are separated by an equatorial band containing nine photometers for measurement of X-ray emissions. The spin-stabilized *Solar Explorer* will be placed in an orbit of 400 statute miles perigee and 630 statute miles apogee. Inclination will be 60 degrees. Expected lifetime is one year.

DOD Shifting T/M Bands

The Department of Defense plans to vacate the 225-260-mc band for telemetering purposes by Jan. 1, 1970, Dr. Albert C. Hall, Directorate of Defense Research and Engineering's deputy director for space, told the International Telemetering Conference in Washington.

DDR&E Director Dr. Harold Brown, in a message to armed forces R&D secretaries, recently informed them that test ranges managed by their departments should review planning to ensure a positive phase-over from the 225-260-mc band to the 1,435-1,535-mc and 2,200-2,300-mc bands by the beginning of 1970. Document MCEB-M92-65, issued by the military communications electronics board recently, spells out the change as it concerns all telemetering activity by the armed services.

The upper 10 mc of the 2,200-2,300-mc band is being reserved for exclusive use in deep-space telemetering, by international agreement, Hall said. Although DOD test ranges are estimated to have more than $150 million invested in present telemetering equipment and functions, most of this investment will be unaffected by the band change and will be directly usable beyond 1970, Hall said.

Changeover for all three of the armed services will cost an estimated total of $60 million, to be spent over the next several years, Hall said.

Spent Titan Parts Return

The Air Force received an unexpected bonus from its second firing of *Titan III-A* last Dec. 10, when some of the tankage and parts of the transtage returned to Earth, impacting in Argentina. These recovered portions are being returned to Air Force System Command's Space Systems Division in the United States for study.

IMP Launch Set

The third *Interplanetary Monitoring Platform (IMP)* satellite is scheduled for launch from Cape Kennedy no earlier than May 28.

IMP-C, part of NASA's *Explorer* series of scientific satellites, will be launched by a three-stage *Delta* booster into a highly elliptical orbit. Planned apogee is 130,000 miles and perigee, 120 miles. Inclination will be

33 degrees. Orbital period for the 130-lb. satellite will be about four days.

The spacecraft, designed to measure magnetic fields, cosmic rays and solar wind, will carry nine experiments.

Philco Gets Shillelagh Award

Philco's Aeronutronic Div. has been awarded a $1.3-million cost-plus-incentive-fee contract for engineering and design to adapt Army's *Shillelagh* missile to replace the 105-mm gun on the M-60 tank. This is the first increment funding of what will be a total $3.5-million effort over a two-year period.

Silo Model Gets Blast

The second in a continuing series of tests to determine effects of high-explosive blasts on missile silos was conducted early this month at Kirtland AFB, N.M. A scale model of a "typical underground missile silo" was subjected to a blast in a program to simulate ground shock effects of nuclear blasts on missile installations.

The effort is aimed toward development of a simulation device that will yield information unobtainable in actual full-scale tests because of limitations imposed by the nuclear test ban treaty.

ALTAIR Pact to Sylvania

ALTAIR, a new Advanced Research Projects Agency long-range tracking and instrumentation radar, has been assigned for development to Sylvania Electric Products, Inc., Waltham, Mass., ARPA has announced.

The radar will be installed on Roi Namur Island in the Kwajalein Atoll in the Pacific, with the project being monitored for ARPA by the Army Missile Command.

Like the Tradex radar now being operated by ARPA on Roi Namur, ALTAIR is a mechanically operated dish type, but is more sensitive and will operate at different frequencies than radars now operated in the PRESS program by the agency. Along with other Roi Namur facilities, the new equipment will aid studies of the physics of vehicles re-entering the Earth's atmosphere.

Funding of the project will total an estimated $20 million, with an additional $5 million earmarked for military construction at the site. Sylvania will receive approximately $2 million for initial fabrication of the hardware.

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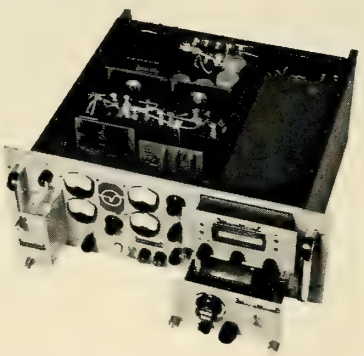

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Schriever Reveals MIDAS Advances

AFSC commander also foresees long-duration military comsat system, three classes of AF boosters beyond Titan III-C

ALBUQUERQUE, N.M.—The Air Force still is devoting a strong effort to a space-based ballistic missile detection system and "giant strides are being made in this field," reports Gen. Bernard A. Schriever, head of Air Force Systems Command.

Schriever's statement to the Aviation/Space Writers Association meeting here May 20 was the first public disclosure of developments in the *MIDAS* program since it was reoriented several years ago after encountering technical difficulties in infrared detection systems.

Schriever said a now-current spacecraft "piggyback" program for background measurements has yielded information of great value.

Technologies now being studied include spacecraft stability, orbital power generation and satellite thermal control. Schriever said rapid transmission and processing of the acquired data and optimum display are also requirements.

● **Looking ahead**—The Air Force Systems Command chief in his speech touched on developments in a number of unmanned and manned space projects. These included:

—AFSC is working on follow-on systems to the present anti-satellite defense systems in the mid-Pacific announced some months ago. He said efforts also are under way to increase the overall effectiveness of the two existing systems.

—Plans were disclosed for three more launches in the *Nuclear Detection Satellite* (formerly *Vela Hotel*) program. Schriever said the two basic satellites in the next launch will have significantly greater detection capability than the four now in orbit, which still are functioning. Completely redesigned spacecraft will then be used in the following two launches to investigate new and improved concepts of nuclear detection. These last two will use the *Titan III-C* booster. He said success of the *NDS* program has enabled it to be moved more than a year ahead of schedule.

—An advanced military communication satellite system is planned in which the expected life of each satellite will increase to as much as three to five years from the one and a half years planned for the 24-satellite random system now authorized for launching in the *Titan III-C* development program.

—Air Force visualizes three general classes of advanced launch vehicle systems beyond *Titan III-C*. These are an advanced expendable booster, a reusable or partially re-usable rocket vehicle that takes off vertically and lands horizontally, and, finally, a fully or partially re-usable vehicle powered by combinations of air-breathing and rocket engines, which takes off and lands horizontally.

The first two could be developed and produced in the near future, Schriever said. The third will require longer development time.

A recoverable first stage is well within the state of the art, Schriever noted, but problem areas include ve-

Minuteman II Emplacement Cost To Top $1 Billion

ALBUQUERQUE, N.M.—Eight hundred *Minuteman I* missiles in five wings located in the central United States will all be replaced by the improved *Minuteman II* missile in a phased modernization program scheduled to cost more than $1 billion, the Air Force announced.

In confirming the decision, Brig. Gen. Harry J. Sands, Jr., Ballistic Systems Division commander, said the *Minuteman II* missiles provide improved range, greater payload, more flexible targeting and greater accuracy. Air Force spokesmen estimate *Minuteman II* kill capability as "eight times that of *Minuteman I*."

The first production model of the advanced second stage for *Minuteman II* has already rolled off the Aerojet-General production line and a succession of tests of the new second stage have been successful. The improved second-stage propulsion is 50% more powerful than that of its *Minuteman I* predecessor and adds at least 700 mi. to the 6,300-mi. range of the *Minuteman I* or "B" version of the missile now operational in Wings 2 through 4, with Wing 5 scheduled to go operational by the end of June at Warren AFB, Wyo.

The *Minuteman I* "A" version in Wing 1 at Malmstrom AFB, Mont., is limited to a 5,000-mi. range. The improved *Minuteman II*, once designated the "C" missile, is now referred to as "F."

The project calls for modifications of existing silos, launch control centers and the ground support equipment designed and built by Boeing, to make the latter perform the same functions as the new *Minuteman II* ground support gear provided by Sylvania. Air Force spokesmen explained that the project is best described as a modernization rather than a retrofit procedure, since an entire new missile will replace each *Minuteman I* removed from its silo.

Under a current program of in-service test firing, randomly selected missiles are taken from their operational silos and fired by AF wing crews selected in the same manner, from Vandenberg AFB. Each test-fired missile will be replaced by a *Minuteman II*, in addition to the programed modernization replacement which will begin at Wing 4, Whiteman AFB, Mo. Whiteman replacement will be followed by Wing 1, Malmstrom; Wing 2, Ellsworth AFB, S.D.; Wing 3, Minot AFB, N.D.; and Wing 5, Warren; in that order.

Completed modernization will give the Air Force a total of 1,000 operational *Minuteman II* missiles. Wing 6, the first to be designed exclusively for *Minuteman II*, is being built at Grand Forks AFB, N.D.

Grand Forks will have a complement of 150 *Minuteman II's*. Fifty missiles will be added at the Malmstrom site, making an eventual total of 200 *Minuteman II's* there. The Warren wing, to be initially equipped with 200 *Minuteman I's*, will also ultimately have 200 *Minuteman II's*. All others will have 150 missiles.

Basic changes between the first- and second-generation missiles are an improved single-nozzle second-stage engine and an improved guidance system employing the microelectronic D-37 airborne digital computer.

hicle separation aerodynamics, materials, refurbishment and cryogenic tankage difficulties.

• **MOL alternatives**—Schriever said two approaches to design of the *Manned Orbiting Laboratory* vehicle still are being considered—*Apollo* and the modified *Gemini*. He left the impression that *Gemini* is strongly favored.

"If the *Gemini* approach is selected, the spacecraft subsystem for the *MOL* would make maximum use of the investment in that program. The military version of the NASA *Gemini* spacecraft, the *Gemini B*, would use 75% of the design and engineering developed by NASA and 85% of the flight and operations experience. Approximately 40% of the *Gemini B* aerospace ground equipment hardware requirements can be met from equipment becoming excess to the NASA *Gemini* program—a large dollar savings."

He also pointed out that early availability of the *Titan III-C* would permit the MOL program to proceed without costly delays. He said the *Titan III* transtage can supply most of the required in-orbit maneuver capability. Schriever cited no advantages in the use of *Apollo*.

He said a later phase of the *SV-5* lifting body re-entry vehicle program now being undertaken in the Spacecraft Technology and Advanced Re-entry Tests program (START) may call for drops of a piloted *SV-5* lifting body from a B-52 mother ship. Data could be obtained on flight characteristics, aerodynamic stability and control. He said these flights would be coordinated with flight tests of other lifting body configurations being investigated by NASA. This phase of the program would provide data from Mach 2 to landing speed.

The early unmanned phase, which calls for four hypersonic flight tests with launch from Vandenberg AFB in 1966-67, would investigate re-entry at orbital velocities and maneuvering flight down to aircraft speeds.

• **Propulsion efforts**—Schriever also said that Air Force is now embarking on a program with NASA to demonstrate very-high-chamber-pressure cryogenic rocket engines. The performance from these engines, which will be throttleable, is expected to increase payloads for recoverable vehicles by 50%.

He said the U.S. cannot afford to ignore the promising propulsion system made possible by supersonic combustion. For this reason, he said, AFSC is pushing development of the supersonic combustion ramjet, known as scramjet. He said aircraft powered by scramjets could travel coast-to-coast in an hour.

He added that performance of basic *Titan III* vehicle can be increased by adding a third-stage *Agena* vehicle, by strapping on two or four standard solid propellant *Minuteman* motors or by increasing the standard 120-in. motors from five segments to seven. "Finally," he said, "156-in. solid motors can be attached to the basic core to provide even greater capability." He said studies have shown that *Titan III* also is readily adaptable to other upper stages now in being or under development, including *Centaur*. ■

Statute May Speed Refund Actions

Dept. of Justice official tells House investigators limitations measure is under consideration; GAO chief airs disagreements with DOD

A STATUTE OF LIMITATIONS on attempts by the Government to get refunds from defense contractors on completed contracts may be requested by the Justice Department.

The measure would answer in part one of the biggest complaints heard by the House Government Operations Military Subcommittee on the practices of the General Accounting Office and the Justice Department in auditing defense contracts. Rep. Chet Holifield (D-Calif.), chairman of the subcommittee holding the inquiry into the efforts of the GAO, voiced his concern that defense contractors are held at a disadvantage while the Government decides what action it is going to take.

GAO usually completes its audit of contracts within three years after termination, Comptroller General Joseph Campbell told the subcommittee. If GAO decides to turn the case over to the Justice Department, it may be many years before the contractor receives a decision on whether there are grounds for legal action against him. Payment may be withheld from him during this time, and, according to Holifield, the contractor has no recourse to the Court of Claims to get payment as long as the Justice Department is weighing its decision.

• **Machinery is slow**—Holifield noted that in one case, GAO claimed that a contractor had received $1.5 million in overpayments or undue profits that should have been recovered by the government. The government agency, however, disagreed. The Department of Justice was asked to look into the case in February, 1960, to reconcile the position of GAO and the agency. No decision has yet been made, said Holifield, and the contractor has not received any funds.

Assistant Attorney General John W. Douglas told the subcommittee that the problem was one of an overload of cases in his department, and that a special committee was looking into the possibility of drafting legislation to enact a statute of limitations. This would give some impetus to getting the case load down, he indicated.

In a second appearance before the subcommittee, Comptroller General Campbell made it clear that GAO differs with the Department of Defense about voluntary refunds on contracts. While DOD takes the position that such a measure is "extraordinary," GAO feels that "retention of an unearned profit or 'windfall' by the contractor or subcontractor" falls under the heading of "contrary to good conscience and equity." This term is in the DOD language on the subject.

Holifield earlier said that contractors should not be penalized for "windfalls," especially objecting to their being put on a formal or informal blacklist when there are no legal grounds for it.

• **Lease vs. buy**—Deputy Director of the Budget Elmer B. Staats revealed that some corrective action may be taken in Armed Services Procurement Regulations (ASPR) regarding the dispute between DOD and GAO over lease vs. purchase of electronic data processing equipment.

Although he did not give details of the new ASPR's, he said he believed they would bring about the results desired, although they were not identical to the solutions recommended by the Comptroller General.

Staats commended the GAO, however, in pointing up the problem and said that GAO "has assisted us materially in raising the proportion of purchased equipment from 15% in 1962 to 50% at this time." ■

Extravehicular Exercise Due in GT-4

Formal go-ahead awaited for experiment calling for McDivitt to open hatch and stand up; other details of flight plans

by Hal Taylor

THE FIRST U.S. extravehicular experiment is expected to be attempted during the four-day manned *Gemini 4* flight now scheduled for the first week in June.

While it is still not officially approved, NASA officials said that they expected a go-ahead shortly before liftoff.

The extravehicular space suit has been fully qualified and it appeared only further testing of the spacecraft hatch at the McDonnell Aircraft Corp. is holding up the approval.

The experiment calls for command pilot astronaut James A. McDivitt to open the spacecraft hatch and stand up in space. He will not leave the spacecraft, however, as Russian cosmonaut Lt. Col. Alexei Leonov did on the *Voskhod II* flight last March. This will not be attempted by NASA until the *Gemini 5* flight later this year.

If the extravehicular experiment is made part of the *Gemini 4* flight plan, it will be further evidence of the space agency's drive to speed up *Gemini* flight operations.

Under the program's first schedule, the extravehicular test was not slated until the fifth mission.

The *Gemini 4* flight does reflect the stepped-up activity. It was originally scheduled for the third quarter of this year. NASA, however, cut more than a month from that timetable and it is now scheduled to blast off from Cape Kennedy June 3 at the earliest.

● **Flight plan**—The 7,000-lb. spacecraft will be launched by the Martin Co.'s *Titan II* booster into an orbit ranging from a perigee of 100 mi. to an apogee of 184 mi.

Each orbit is expected to last about 90 min. and range between 33° north and south of the equator.

Orbital insertion will occur about 680 mi. from Cape Kennedy at a velocity of 25,766 fps (17,567 mph). This will include a velocity of 10 fps provided by the spacecraft's aft firing thrusters during separation from the *Titan II's* second stage.

Retrofire is planned at 97 hrs., 31 min. and 43 sec. after liftoff as the spacecraft passes over the West Coast of the U.S. before the end of the 62nd orbit. Landing is expected approximately 17 min. after retrofire in the Atlantic Ocean about 400 mi. south of Bermuda.

Prime objective of the flight is to gather data on the effects of extended space flight on crew performance and physical condition. *Gemini 4* will also triple the amount of U.S. manned spaceflight experience. Up to this point, NASA flights have accumulated nearly 65 manhours in space. The two-man, 62-orbit flight will bring the total to about 257 hrs.

Astronaut Edward H. White will serve as pilot during the flight. The backup crew—which would take over if anything happens to either McDivitt or White prior to liftoff—will be astronauts Frank Borman and James A. Lovell.

● **Preparing for rendezvous**—The upcoming flight will also serve as a test for future rendezvous and docking missions. Ten separate orbit-changing maneuvers will be made by the two-man crew as a further test of the spacecraft's orbital attitude maneuvering system.

The in-orbit maneuvers will total 55-fps changes in velocity and will be used to adjust the orbital lifetime of the spacecraft. Additional maneuvers totaling 25-fps changes in velocity will be used to check out flight operating procedures.

The command pilot will not control the spacecraft attitude during the first two seconds of thrust. From that point on, he will control attitude to zero degrees roll, zero degrees yaw and minus 20 degrees pitch for the remainder of the burn.

Another important maneuver will take place on the second orbit when the forward velocity will be increased by 7 fps to raise the perigee to 105 miles and insure a five-day orbital lifetime. Prior to the burn, the command pilot will yaw the spacecraft 180 degrees. The two forward-firing 85-lb.-thrust engines will be used for the maneuver.

● **Experiment breakdown**—Eleven experiments are planned for *Gemini 4*. Three of these are medical, four engineering, two DOD and two scientific.

The medical experiments will study effects of exercise and work in space, time-heart contractions with a phonocardiogram, and also determine whether bone demineralization takes place on long space flights (see p. 28).

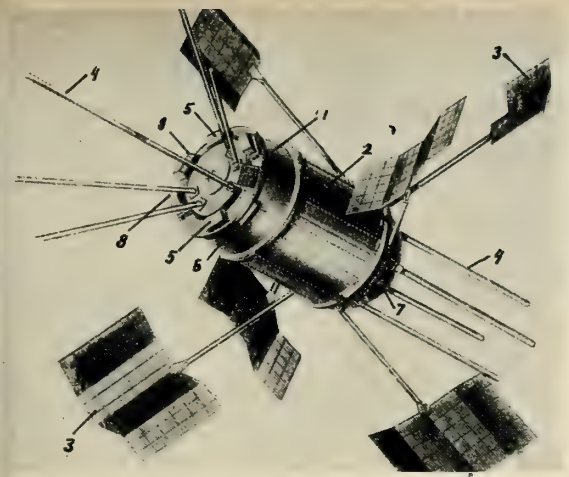
Engineering experiments will measure electrostatic charges on the spacecraft surface, measure radiation immediately around the spacecraft, monitor direction and amplitude of the Earth's magnetic field with respect to the spacecraft and make two-color photographs of the Earth's "limb" (the outer edge of brightness).

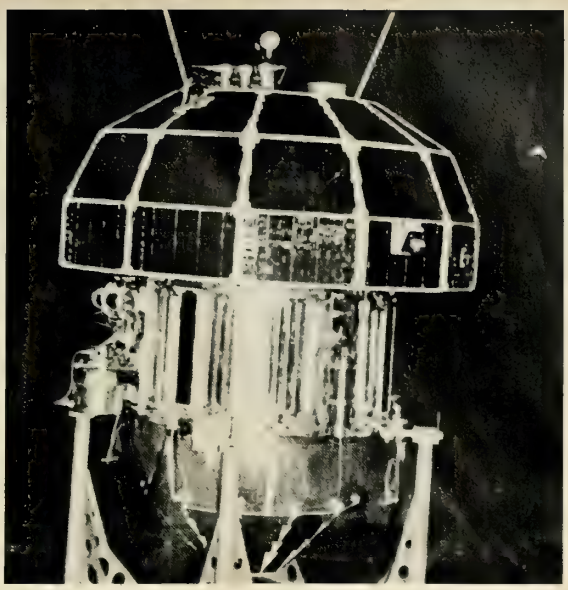
DOD experiments involve radiation measurements inside the spacecraft and simple devices for navigation.

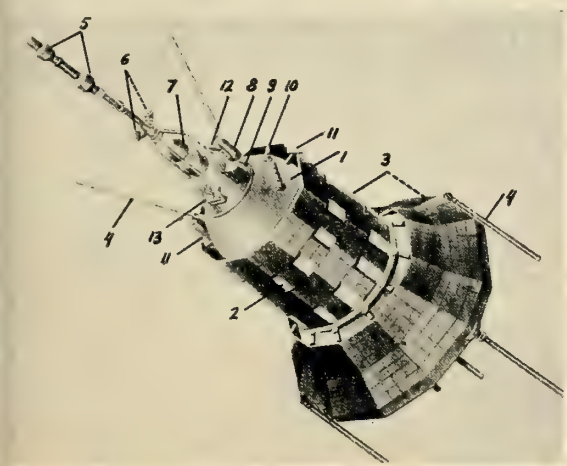
The scientific experiments include wide-angle terrain and weather photography.

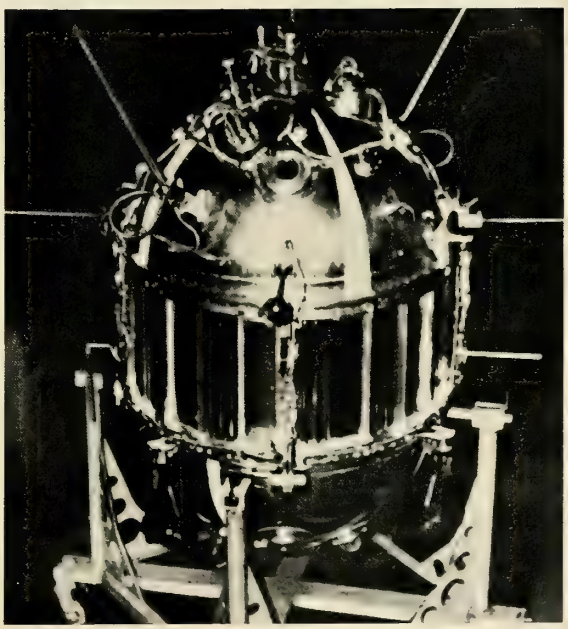
The upcoming flight will mark the first time that mission control will be exercised at the Manned Spacecraft Center, Houston. The Mission Control Center at MSC was used to monitor the *Gemini 3* mission, but control of that mission and all the *Mercury* manned space flights was maintained at Cape Kennedy. ■

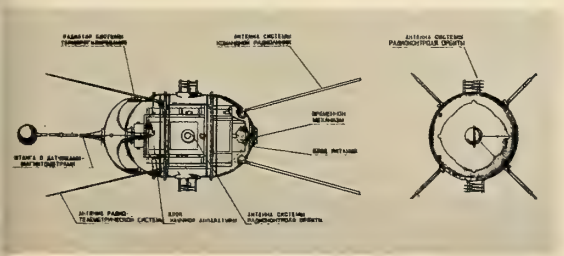
ASTRONAUT James A. McDivitt, command pilot for GT-4 mission, is placed in his flight seat for weight and balance testing at Cape Kennedy. Astronaut Edward H. White II is pilot.











New Pictures of Elektron and Cosmos

SOVIET DELEGATES at the recent Post-*Apollo* Space Exploration Symposium in Chicago (M/R, May 10, p. 12) made the first release of these pictures of *Elektron* and *Cosmos* spacecraft.

TOP LEFT: Elektron I Cosmic Station: 1) airtight housing; 2) louvers of heat control system; 3) solar batteries; 4) antennas; 5) micrometeor detector; 6) device for recording corpuscular radiation; 7) mass spectrometer; 8) proton detector; 9) device for studying energy spectrum of electrons in radiation belt. MIDDLE LEFT: Elektron II Cosmic Station: 1) sealed housing; 2) louvers of heat control system; 3) solar batteries; 4) antennas; 5) magnetometer; 6) solar orientation pickups; 7) spherical analyzer for studying energy spectrum of low-energy particles; 8) device for studying chemical composition of cosmic rays; 9) device for studying energy spectrum of electrons in radiation belts; 10) mass spectrometer; 11) device for investigating X-ray radiation of Sun; 12) detector of low-energy protons; 13) charged particle traps. BOTTOM LEFT: Drawings of Cosmos. RIGHT: Photos of two versions of Cosmos series. Details were not immediately available.

COSPAR Meet Stresses Cooperation

Soviet physiologist says visual cues are key to cosmonaut extravehicular orientation; British research rocket detailed

by William S. Beller

MAR DEL PLATA, ARGENTINA—Delegates to the 1965 COSPAR (Committee on Space Research) meeting left this seaside resort area last Friday feeling that they had struck several strong blows for international scientific cooperation.

They arrived two weeks ago in Buenos Aires, where the meeting had been scheduled to take place, to be greeted by student riots and "Yankee go home" placards. The meeting was hurriedly shifted here to avoid possible embarrassing encounters between demonstrators and U.S. delegates (M/R, May 17, p. 9).

COSPAR was established by the International Council of Scientific Unions, and the current gathering was the organization's sixth international space science symposium and eighth plenary session. It ran May 10-21.

Soviet scientists shared some of their *Voskhod* physiological data with their colleagues, but one high-ranking U.S. Government official felt that the effort was inadequate. He decried the sight of researchers "panting like dogs for a few morsels from the Soviet table." And he pointed to the volume of available scientific data on U.S. astronauts in comparison with the "meager fare" furnished by the Soviets.

(For a more complete report on Voskhod medical findings than was presented at the COSPAR meeting, see p. 31.)

Highlights of the second week of meetings included a description of the phenomenal success of the fully stabilized British *Skylark* rocket in obtaining new astrophysical data, and a prediction of a revolution in meteorology.

Space medicine—Cosmonouts have no difficulty knowing the orientation of their bodies and experience no nervous disorders if they are given visual cues. These could be the spacecraft itself or markings or protuberances on it.

This was one of the conclusions of O. G. Gazenko, Soviet physiologist and member of the Soviet Academy of Sciences. He based his remarks on the experiences of Soviet cosmonauts, particularly those of Lt. Col. Alexei Leonov in *Voskhod II*.

"When he saw the spacecraft, he had no problem knowing his orientation, but it was different when he didn't see the spacecraft, when he turned his back. Then it was almost impossible for him to determine whether he was up or down."

Gazenko emphasized that under a weightless condition, "work (for cosmonauts) is an important normalizing factor."

He said that inactivity leads to illusion formation but that deep sleep or full activity is best. "Great activity of the cortex is optimal," he said.

Gazenko also laid great stress on the enormous adaptability of the human organism, and advised using this factor as one of the criteria in selecting and training cosmonauts. He suggested using mountain climbing as part of cosmonaut training for non-specific adaptations.

For specific adaptations, he advised thorough training to assure that the cosmonaut is not sluggish in his responses during the acceleration and emotional periods of launch and reentry.

At the beginning of one of the *Voskhod* flights, it took cosmonauts twice as long to make some physiological measurements compared with performance time later in the flight. Similarly, during both *Voskhod* flights, the handwriting of the cosmonauts improved from orbit to orbit. "However, in the field of well-trained skills, there were no problems or slackening," Gazenko said.

● **Extravehicular experience**—Speaking of Leonov's experiences outside his space capsule during orbital flight, Gazenko said even comparatively small efforts resulted in body rotation with relatively high angular velocity. Nevertheless, "the cosmonaut had completely adequate coordination of his movements and could move with the aid of his rope and could do his work adequately." The rope was described as carrying only "a communications wire."

Gazenko added that new bodily coordination skills may have to be learned and others suppressed under weightlessness.

Dangers to cosmonauts occur when the spacecraft goes from an accelerated state to a weightless state, and from a weightless state back to an accelerated one, Gazenko told the COSPAR delegates. Re-entry is the more difficult state.

During the launch phase, the cosmonauts' pulse and breathing rates were greater than noted during centrifugal tests, in ground laboratories. In *Voskhod II*, it took a comparatively long time for the normal levels to be reached, according to Gazenko. He stressed that cosmonauts must be selected on the basis of overall psychological and physiological factors—not isolated ones.

Comparison of the data of the *Voskhod* flights with other space flights showed the crews having fewer cardiovascular variations and better responses to stress. He recommended crews of several people since "the feeling of togetherness of cosmonauts is very important."

Astrophysics—U.S. scientists were frankly envious of the research possibilities in astrophysics offered to their British colleagues through the fully stabilized *Skylark* rocket. The best the U.S. has is the *Aerobee*, whose payload is stabilized only in pitch and yaw. The *Skylark* is stabilized along all three of its axes, allowing relatively long continuous looks at the Sun or other astronomical bodies.

"It's unfortunate that the stabilized rocket is not progressing as fast in America as British work indicates it could," Herbert Friedman, Naval Research Laboratory scientist, told MISSILES AND ROCKETS.

Some very important scientific data relating to solar physics recently gathered by stabilized *Skylarks* were disclosed at the COSPAR sessions.

● **Vehicle described**—The *Skylark* is a single-stage, solid-fuel rocket that comes in one of several motor configurations. Typically, the rocket can carry a 150-200-lb. payload to a 200-km altitude. Britain has flown the vehicles since 1957, the hundredth firing taking place a few months ago. These were all unstabilized versions.

Work on the stabilized *Skylark* began in 1962, and the first three prototypes have all been fired. They performed perfectly, according to reports. The Royal Aircraft Establishment at Farnborough was responsible for systems management of the stabilized *Skylark*, and Elliott Automation for the control system.

The *Skylark* uses the Sun as a reference point, just as the *Aerobee* does, and achieves pointing accuracy of between two and three minutes of arc in pitch and yaw, reports one of its users,

Kenneth Pounds lecturer at Leicester University, England.

In the *Aerobee,* only the payload unit is stabilized. The entire upper section of the *Skylark* rocket is stabilized, the lower portion having been ejected shortly after launch. This method gives the British rocket a proportionately larger payload volume and weight.

Pitch and yaw control of the *Skylark* is similar to the *Aerobee*'s. Solar error signals are generated by means of photocells and slit arrangements and fed into two gas-jet systems.

Another error signal is taken from a magnetometer in the *Skylark* control unit for full stabilization. This signal actuates a third gas-jet system, which controls roll by maintaining a constant value of magnetic flux. In other words, the *Skylark* uses the magnetic field vector as the second reference axis.

"The new *Skylark* has revolutionized the whole field of rocket research as far as we're concerned," said Pound. He pointed out that many scientific experiments, such as taking an X-ray photograph of the Sun, could not be done by an unstabilized rocket. "You need 100 sec. or more exposure time, plus roll stabilization, or the photographs will be blurred."

● **X-rays enlightening**—Pounds showed COSPAR delegates some new X-ray photographs of the Sun. "Undoubtedly the best ever seen," said one of the delegates. They were taken by *Skylark* cameras pointing at the Sun for about 230 sec.—the exposure time beginning when the rocket rose above the absorbing layer of the atmosphere, at about 100 km.

The photographs showed limb brightening on the solar surface but dark polar regions. Moreover, the X-ray pictures showed bright spots occurring wherever there were plages. These conditions were predicted theoretically several years ago by Gerhard Elbert of Lubingen University, West Germany, but not observed until now.

In the second set of *Skylark* experiments reported on at COSPAR, Robert Wilson, head of spectroscopy division of the U.K. Atomic Energy Authority, told of getting chromospheric ultraviolet spectra. He was able to increase the pointing accuracy of his instrument to within two or three seconds of arc by means of a servoed mirror arrangement. For the first time, scientists were able to see resolutions of emissions from a small height in the chromosphere. Emission lines greater than 2,000 Angstroms were revealed, lines that previously had not been seen because they were masked by the light from the photosphere.

This summer the next phase in *Skylark* development will take place. It is expected to be completed by the end of the year. Yaw and pitch accuracy of the rocket will be increased to about 10 to 15 seconds of arc and roll to less than half a degree of arc.

Pounds told M/R that the first experiment to be flown on the new *Skylark* will be a galactic X-ray spectrometer. "Here we shall scan regions of the center of the galaxy which were recently found to contain one or more X-ray sources," he said. "By using a finely collimated instrument, we hope to resolve the X-ray features to one second of arc, that is, determine the fine structure of the galactic center in the X-ray spectra."

Next year, Pounds expects to have a lunar-pointing version of the *Skylark,* which will enable scientists to make ultraviolet studies of the stars.

Meteorology—International cooperation in the atmospheric sciences could soon bring about a breakthrough in meteorology and man's ability to modify and control the weather. This was the thesis of Thomas F. Malone, chairman of the committee on atmospheric sciences, U.S. Academy of Science. He said that weather predictions "two or three weeks in advance are a legitimate scientific goal for the immediate future."

To achieve these goals, he called for a vastly increased number of observations on a world-wide basis. These could be obtained by weather balloons queried by satellites themselves, by rocket launchings, permanent weather stations, and conventional means. These data would be fed into computers "a hundred times larger than those we have today" where a mathematical model of the behavior of the atmosphere had been stored. The outputs would be used for weather prediction or control.

"As the mathematical models take on added complexity to reflect the complexity of the atmosphere, even larger computers will be required," Malone said. Extensions of predictions beyond two or three weeks to provide statistical distributions of states of flow would provide an insight into the physical basis of climate and "would be an essential step in exploring the scientific possibilities and practical limitations of large-scale climate modification."

● **Indian contribution**—A paper by a scientist from India, reporting on information gleaned from rockets fired from the equatorial station at Thumba, was acclaimed as the forerunner of an important new flow of data.

First rocket probes to be fired at low latitudes for meteorological purposes, the Indian series will fill in some gaps in knowledge of the pattern of circulation of winds in the upper atmosphere.

M. S. V. Rao, reporting on the Thumba experiments conducted on World Days during the current International Quiet Sun Year period, said eastnortheasterly winds with speeds of 60-90 knots were observed in the stratosphere during the monsoon. In the mesosphere, data revealed a region of unusually strong winds with high shear. Rao reported that radar observations of the rate of dispersion of chaff confirm the existence of this complex pattern of high shears and pronounced turbulence in the equatorial mesosphere in the monsoon season.

Winter data showed generally moderate easterly flow up to altitudes of 30 miles, Rao said, instead of a cyclonic circumpolar vortex. Even above that height, westerlies were noticeable only during part of the winter. However, instability and marked turbulence prevailing above the stratosphere during the monsoon season disappeared in winter.

NASA scientists at Wallops Island, Va., made a simultaneous series of rocket launchings during the Thumba experiments, in order to get a synoptic picture. Arnold Frutkin, NASA director of international programs, said at the COSPAR meeting that "these data were the first relating to the monsoon problem on a global scale. It shows what very important work (less advanced) countries can do, and what they are interested in." ■

Apollo Plan Conceded To Be 'Most Economical'

SOVIET DELEGATES at the COSPAR meeting conceded that the U.S. *Apollo* approach of detaching a spacecraft from a mother ship already in lunar orbit is "the most economical plan" for manned lunar landing.

The comment was made at a news conference during which the Russian spokesmen were repeatedly questioned as to what method the USSR expected to employ. Asked whether their planning called for direct flight, a system similar to *Apollo,* or flight from Earth-orbit rendezvous, Soviet astrophysicist A. G. Massevitch responded in English: "You'll find out when (the manned lunar landing) is achieved."

A. A. Blagonravov, chief Soviet delegate, said that in view of the difficulties of soft landing on the Moon, the Russians probably will try another soft-landing *Lunik* before attempting to land cosmonauts. He said the lunar surface must be known in detail and "should be examined by automatic stations." Because of the problems involved, he added, "it is not possible to set any date for a lunar landing."

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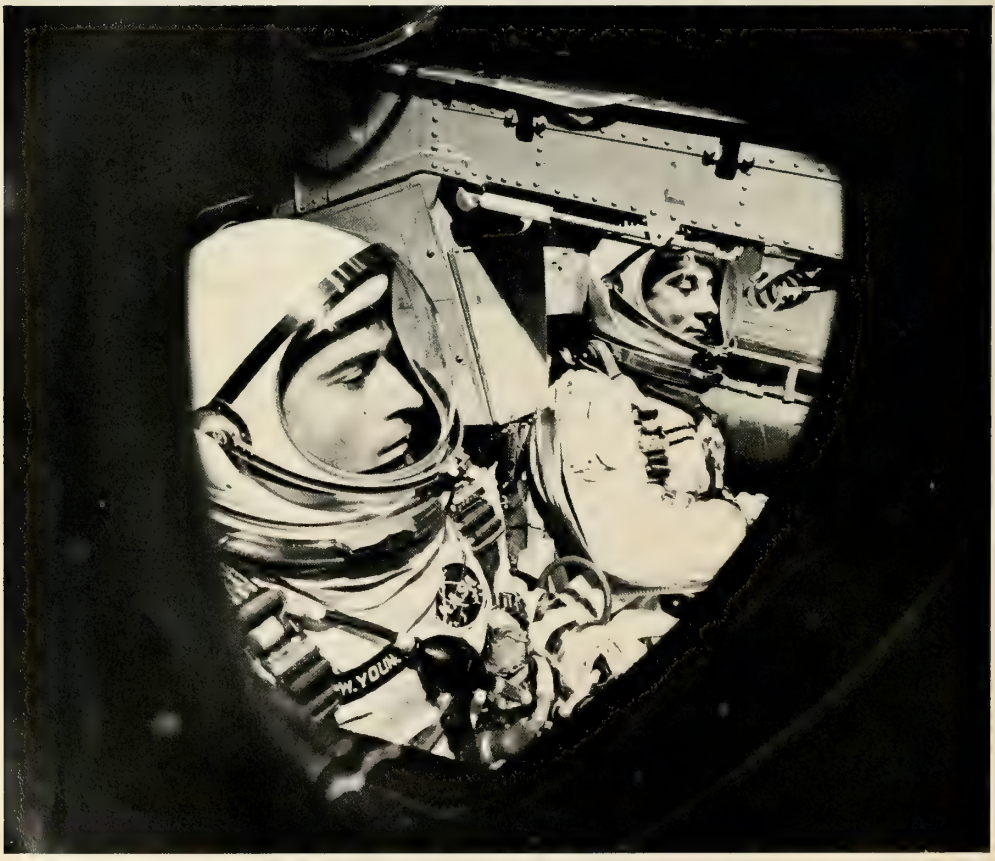
U.S. SPACECRAFT: ASTRONAUTS JOHN YOUNG AND VIRGIL GRISSOM IN GT-3 GEMINI



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PROPULSION

Hydrogen Ramjet Facility Disclosed

Garrett Corp. research leading to the recently awarded NASA contract for studies into a liquid hydrogen-fueled hypersonic ramjet engine was conducted at its new San Tan remote test facility 35 mi. southeast of Phoenix, Ariz. The installation, which began operations less than a year and half ago, was conceived primarily as an extension of the AiResearch Phoenix test laboratory facilities for testing with cryogenic fluids. Equipment includes complete facilities for storing and handling helium, hydrogen, nitrogen and oxygen at cryogenic temperatures, and a rail-mounted 32,000-lb.-force sine and random shaker for testing items under extreme vibration.

ELECTRONICS

Space Suitable for Long Component Life

Following more than two years of cumulative operation in orbit of *Syncoms 2* and *3*, during which one non-castastrophic failure in a transistor was found, Hughes Aircraft engineers conclude that "the space enviroment at 22,000 mi. altitude is more suitable for long life than is the ground. This perhaps can be best explained by the absence of people handling the equipment plus a completely vibration- and atmosphere-free environment in space." This bodes well for future operations in space—but only if rigorous quality control is exercised, it is pointed out.

ASTRONAUTICS

T-33 Jet Simulates M-2 Flight

Handling qualities of the M-2 lifting body during later stages of re-entry and during landing approach are being simulated with a specially equipped T-33 jet aircraft at Edwards AFB, Calif. Wing-tip pods that contain pilot-controlled drag devices permit the T-33 to attain a 2.5:1 lift to drag ratio. In the studies being conducted jointly by NASA and Cornell Aeronautical Laboratory, Buffalo, N.Y., the landing approach begins at about 23,500 ft. and includes a 360-degree turn at a constant glide angle at about 250 kts. Simulation ends 600 ft. off the ground.

MATERIALS

Water Glass for Space Foams

Laboratory experiments with sodium silicate suggest its use as a foam structural material. Herbert I. Hoffman, senior research engineer at Southwest Research Institute in San Antonio, Tex., produced water glass foams using a microwave furnace. The foams could be created through solar energy. Lab samples of the noncombustible material weighed 10 lbs. per cu. ft. The sodium silicate will evolve into a finer, more expanded form if subjected to heat more intense than that which caused initial foaming, says Hoffman. Both sodium silicate foam and film can be made insoluble for military and other terrestial expandable structures.

Projectile Speed Record Smashed

A world speed record of 25,300 mph for controlled flight of a visible object of known mass and shape, over a known distance in a ground facility is claimed by NASA's Ames Research Center. The speed was achieved with a 20-ft. light gas gun firing a 0.05-gram, .22-cal. polyethylene cylinder. It was 3,200 mph faster than the previous record for ground-based controlled projectile flight. The vacuum flight chamber was pumped down to 1/700th of normal atmospheric pressure. The projectile made a crater 0.75 in. across and 0.3 in. deep in a block of hard aluminum.

Vacuum Gauge Range Extended

An ultra-high vacuum gauge calibration system capable of push-button operation in a range from 50 torr to 10^{-10} torr with a precision of $\pm$ 4% will be used in the *Apollo* and related space simulation, satellite and pure research efforts. Developed under a $77,000 NASA contract by National Research Corp., the system is based on known pressure drop of gases through precisely machined orifices. The 40-in.-long, 8-in.-dia. unit is divided into four chambers with three pressure reduction stages. A McLeod gauge is connected to the system as a reference standard while the gauge to be calibrated is attached to the fourth chamber. The Norton Co. subsidiary designed the system for the Marshall Space Flight Center.

SPACE MEDICINE

Long Term Diet Formula Tested

The second long-duration test of a new formula diet developed by the Air Force for space flights has begun at the School of Aerospace Medicine. The liquid diet, which tastes like a vanilla milkshake, will provide the two crewmen with the exact amount of calories deemed suitable for their body weights and metabolic requirements. One man, weighing 115 lbs., will dine on 1,910 calories per day; the other, weighing 174 lbs., 3,113 calories. Calibrated exercise will be performed to test the effect of the new diet on energy. Atmosphere within the chamber will be 50/50 oxygen/nitrogen, at about 19,000 ft. pressure for 30 days.

Cell Radiation Sensors Developed

Highly sensitive detectors to measure radiation damage to single cells of the human body are being developed by Avco Corp.'s Tulsa Div. The instrument, made of special plastics and gases having the same radiation and absorbtion characteristics as human muscle tissue, are being built for the Air Force Weapons Laboratory at Kirtland AFB, N.M. The sensing device is a small plastic cylinder filled with gas, the pressure of which is maintained at a value simulating one micron of wet muscle tissue.

Interior Astronaut Suit Designed

A contract for development of a fabric for wear by *Apollo* astronauts within the spacecraft command module has been awarded to Fabric Research Laboratories. The coveralls will be light-weight, non-flammable, non-toxic, and able to absorb and transmit perspiration in a hot, humid atmosphere.

Advanced TM/MDI Proposed for 3-T's

Integrated system designed by Mayo-Wells is aimed at putting Navy's missile telemetering on par with the state of the art

by Charles D. LaFond

THE NAVY NEEDS both an advanced tactical telemetering system and an advanced tactical miss-distance indicator (MDI) system for its Three-T missiles—*Terrier*, *Tartar* and *Talos*.

Wilfrid J. Mayo-Wells, an internationally known telemetering system expert and consultant to the Navy, has presented a highly advanced, integrated TM/MDI design to interested groups within the Dept. of the Navy and the Applied Physics Laboratory of Johns Hopkins University.

The proposed system employs either true radio Doppler or TV sensor techniques combined with a state-of-the-art telemetry arrangement utilizing a NASA-proved pulse-amplitude modulated/phase modulated (PAM/PM) and microelectronics design.

Mayo-Wells disclosed to MISSILES AND ROCKETS that his proposals are designed not only to restore the Navy's missile telemetering system to the state of the art, but to provide TM and MDI in a tactical system for all of the Three-T missiles—a capability not now available.

● **Test and operational needs**—Reliable miss-distance information can be a necessity for any missile—not only for training, exercise or system evaluation, but also during tactical firings. For the Navy, such data are needed in real time by the launching vessel and other, associated ships.

Of equal or greater importance is real-time damage assessment data.

Data could also include the influences of or evidence of enemy RF jamming and systems malfunctions, and natural and friendly interferences might be detected and obtained.

The advanced integral telemetering system as put forth by Mayo-Wells may well provide a simplified and reliable means to obtain such a data link between missile, target and ships.

● **Three principal approaches**—The MDI system presently employed by the Navy for evaluation, said Mayo-Wells, requires a cooperative target. It requires a target beacon and employs two air-borne-to-ship RF links—one from missile to ship and the other target to ship.

This obviously cannot provide for data collection in a tactical system.

Mayo-Wells proposes two approaches for a tactical system and a third for non-tactical situations.

He suggests the use of four one-inch infrared vidicons in the missile flight-hardware portion of the MDI. Each vidicon element would provide 60° scan capability with a 23-micron maximum senistivity. The only other flight hardware required would be an advanced telemetry transmitter.

Aboard ship, the receiving station would require a single RF receiver instead of the three now used for the Three-T missile series. Mayo-Wells also suggests that such a TV flight system could provide adequate homing data to reduce the size of the existing radar-seeker guidance heads, and possibly eliminate the illuminating shipboard radar in the semi-active guidance.

A second approach would call for using, instead of TV, a very stable oscillator (of the order of one part in 10^7) to phase-modulate another RF transmitter. The latter actually might be the final stage of the integral telemetry transmitter. It would be used to excite an antenna lens for direction of a signal toward the target. The resulting RF echo would be returned to the ship.

To limit the target-beamed radiation until the last few seconds of closure, said Mayo-Wells, lens excitation could be attenuated until "the final stages of homing require antenna power to a specific level."

Because of the expected backward scatter of radiation from the lens or antenna, energy would be transmitted from missile launch to warhead detonation. The MDI transmitter, excited by the stable oscillator, could be used in a tactical situation to produce a back-scatter canceling emission. By rapidly increasing output power level when required, the balanced radiation condition would be overcome and the target illuminated for homing.

The existing Three-T telemetry system could be used for training and evaluation purposes; however, Mayo-Wells proposes updating the hardware to more closely approach current packaging state of the art.

● **Damage assessment techniques**—The IR vidicon elements in the missile would be arranged to provide essentially 360° forward coverage with a 180° spherical field of view. Using integrated circuits and micro-strip fabrication techniques (according to RCA designers who studied such a subsystem using the RCA 1-in. vidicon camera) a very compact subsystem could be built to serve as a driver for modulating the telemetering transmitter.

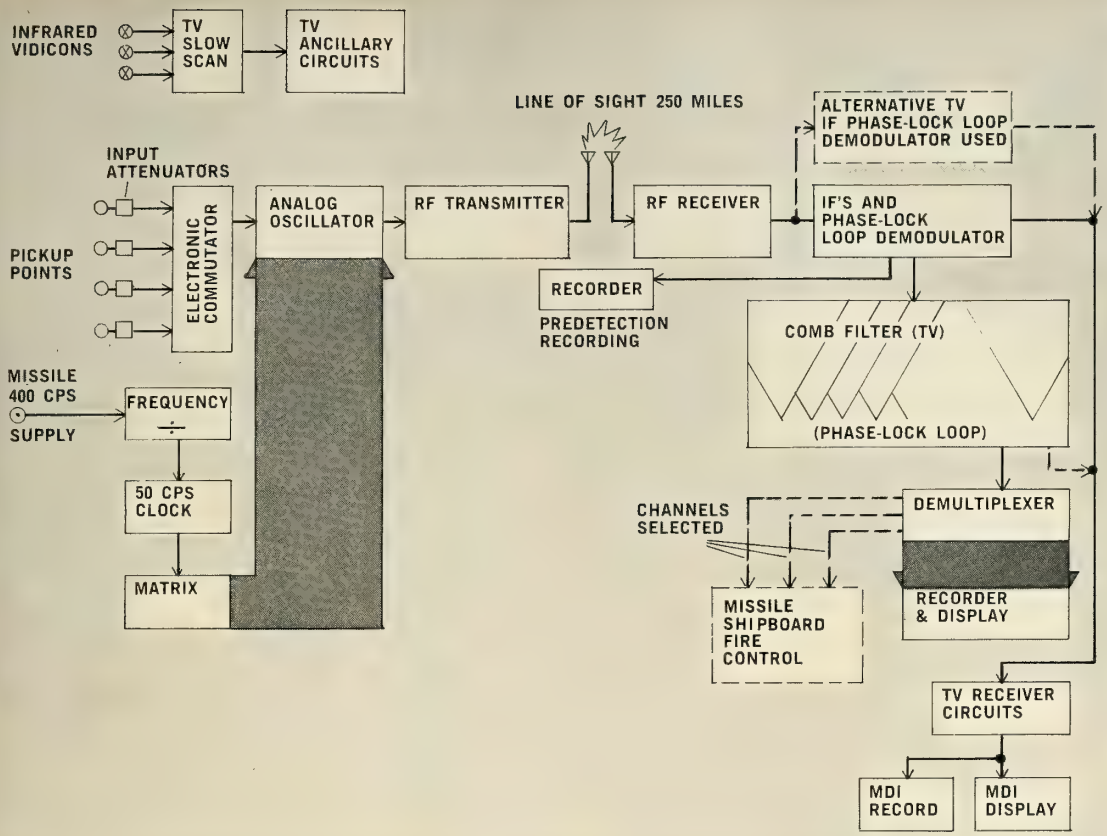
Although the TV head would scan the target continuously, data-compression techniques would be employed to minimize bandwidth requirements. The shipboard receiver system could restore the data as necessary.

To obtain damage assessment data, use of a sub-rocket sensor package was proposed by Mayo-Wells. The technique, using TV, already proved feasible by the Army, involves ejection prior to missile warhead detonation of a small instrumented sub-rocket containing an IR mosaic detector. (This sensor was developed by NASA for micrometeoroid impact detection.) The rocket would hold the package at a safe distance from the detonation zone to prevent damage. The unit would carry a small simple transmitter able to send hit-detection data back to the launching vessel.

● **Advanced telemetering**—A system is needed to effectively handle the upcoming changeover from the 225-mc to the 2,250-mc band, reduce the size, weight and complexity of both the airborne and shipborne subsystems, and provide a means for a single integrated TM/MDI link using only one shipboard RF receiving head.

PAM/PM telemetering techniques are proposed for the flight system by Mayo-Wells. Integrated circuits and solid-state matrix commutation would be employed to sweep the 40-50 data channels at a rate of 50 channels/sec.

A single analog oscillator would be used to phase-modulate the RF trans-



Block Diagram of Advanced Telemetering & TV/MDI Tactical System

mitter/rear-directional antenna.

The shipboard system would employ a phase-lock PAM/PM receiver with 220/2200-mc. band capability. State-of-the-art comb filters would be used to assure ± 1% data accuracy.

A tactical display for each data channel and a recording system complete the basic hardware.

● **System advantages**—The MDI system proposed by Mayo-Wells would make use of the new 2.2-2.3 gc band which must be used in all telemetering systems by January, 1970.

Mayo-Wells believes that use of state-of-the-art electronic-design techniques would make the system suitable for tactical use and achieve a meaningful increase in reliability. The proposed system would require only a 1 to 2 sec. warm-up, considered satisfactory for any foreseeable situation.

Compact design of the proposed systems aboard ship would permit installation of subsystems down to the multiplexers at the antenna location, thus improving the local S/N ratio and greatly improving performance.

● **Existing MDI system problems**—Many experts feel that the existing MDI/telemetering system used is of marginal value, when not only systems operational limitations but operator problems are taken into account.

The basic theoretical principle of the cooperative radio Doppler system is considered sound for most applications other than tactical. In actual operation, however, performance to date leaves much to be desired.

Reports from Naval Ordnance Laboratory-Corona, the Applied Physics Laboratory, and elsewhere have indicated that the performance difference results from:

—Noise, probably due to 400-cps cross-talk, on the telemetered record;

—Excessive signal-to-noise ratio problems caused by the great distance between the MDI shipboard antenna and the receiving station;

—Excessive equipment warm-up time; and

—Crew problems resulting from poor training, low interest and general lack of training material.

● **Telemetry installations in use**—Three types of shipboard telemetry installations are now in use: The UKR-8, UKR-10 and SKQ-1 in *Terrier* ships, the latter two in *Talos* and *Tartar* ships.

The *Terrier* and *Tartar* tactical systems reportedly do not offer sufficient channel capability to identify jamming in all instances. Also, it has been reported that data transmitted are insufficient to provide a complete reliability check in the event of failure of the missiles in the kill function.

The UKR-10 system has often been termed "beyond the average level of crew capability."

The same MDI system, USQ-11, is employed on all the Three-T ships. Shipboard stations employ the SKH-1, UKR-10 and the SKQ-1.

In general, MDI data have been reported inferior to normal telemetering data. Operational performance of the MDI systems varies widely from ship to ship and with increased range.

Critics say the present system is not only oversize, overweight, and overly complex, but fails to provide damage assessment information and suffers from excessive overall failure rates. ■

Ground Conveyance Under Scrutiny

MIT study for Commerce Dept. due in June; more RFP's expected this summer; aerospace firms demonstrate interest

by Michael Getler

RESULTS of a detailed six-month study of the state of the art in high-speed inter-city ground transportation, performed by a team of engineers at Massachusetts Institute of Technology under a $500,000 Department of Commerce contract, will be presented to the Department's Northeast Corridor (NEC) project office next month.

The report and its recommendations are expected to provide the impetus for the first important burst of funded research by the Department aimed at solving the long-range problems of inter-city travel for the increasingly congested 500-mile span between Boston and Washington. The NEC project office is headed by Dr. Robert A. Nelson.

The Commerce Dept.'s budget request for FY '66 includes $20 million to begin a comprehensive program of R&D in this field. The funds could well be a harbinger of a radically different form of high-speed (200-400 mph) travel for the 1980's costing several billion dollars to install. The aerospace industry is in a strong position to contribute greatly to such a project from both the technology and management standpoints.

Project officials told MISSILES AND ROCKETS that "aerospace firms have been parading through here in recent months. Some have left systems management proposals, which, while interesting, are premature. Others have put material on file describing the firm's capabilities and programs in this area."

Those who have already shown interest in the program are: North American Aviation, Hughes, Westinghouse, General Electric, General Motors Defense Research Laboratories, United Aircraft, Stanford Research Institute, Aerojet-General, Kaiser Engineering, Hazeltine, Cornell Aeronautical Labs, Litton, Goodrich, American Machine and Foundry, McDonnell, Illinois Institute of Technology, and Republic Aviation.

● **Funding allocation**—The Commerce Dept. funding request breaks down into three categories: $10 million for R&D on new high-speed ground systems and components; $8 million for demonstration projects aimed at showing what improvements can be made in rail transportation using current state-of-the-art equipments and techniques; and $2 million for a nationwide program to improve collection of statistics dealing with all modes of transportation to aid evaluation of all proposals.

While even attempts to make interim improvements in current rail systems will create a sizable amount of new business, the degree of innovation and the dollar market are very modest in comparison to the revolutionary travel modes and technologies to be researched as part of the $10 million to be spent for new systems R&D.

The MIT study includes a complete state-of-the-art survey of current inter-city travel means, both ground and air. The study also looks into many of the concepts for new forms of ground transportation that have been put forward in recent years and will make recommendations concerning the potential for some of these.

It may also recommend some new approaches, and, most importantly, call out those systems or components that should be pursued with additional research. Based upon preliminary MIT reports, Commerce Dept. officials say "the prognosis is that substantial results from the investment of modest amounts in R&D will be forthcoming. This is in part attributable to a recognition of the transferability of technologies from the defense and space programs," they report.

● **RFP's expected**—With the MIT study in hand, Commerce Dept. officials told M/R that first RFP's will go out to industry and universities possibly by mid-summer for research into areas such as suspension techniques, propulsion, control and vehicle design. Actual awards are expected to be made in the fall, and Commerce Dept. officials say anywhere between 15 and 50 contracts could be awarded.

Pending results of this research and an extensive series of in-house benefit-cost surveys, which are already underway and are to be carried on over the next two years, project officials expect they will be able to set forth recommendations and a set of alternatives to the Secretary of Commerce and the Administration in the summer of 1967.

The benefit-cost studies by the Department are of prime importance. "Our major problem," says Edward J. Ward, chief of engineering and research for the project, "is not really technology, but economics. We've got to generate a system that can attract business and make a profit without a subsidy."

Although interim improvements are important, Ward says "we won't really attract people off the highways by just a modest improvement. We must introduce a means of travel which must be obviously better in time, convenience, and cost. I think we would have to equal air transportation in door-to-door elapsed time which means at least a 200-mph system."

Ward says current statistics show that 90% of inter-city travel is by auto, which makes it the prime target for attracting passengers to a new travel mode. The airlines reportedly get 6% of the total and rail and bus split the remainder, with rail getting the larger share. Ward stresses that while the initial project is aimed at the Northeast section of the U.S., the techniques will be applicable to similar length, high-density corridors throughout the country.

Several high-speed ground systems have been proposed and under study for years. These include concepts for automated highways, train-auto ferries, air-cushion vehicles riding on a variety of different rail-type guideways or concrete troughs, and jet-engine-driven or pressure-differential-powered vehicles that ride through tubes several hundred feet below ground.

While the MIT study and the Commerce Dept. in-house efforts will take a look at all these and some new ones, there are already some advantages shaping up for particular systems and components, and some obvious areas of potentially high-yield research, even though the project is still in its very early stages.

For example, engineers here say that automated highway systems do not appear to be the solution to inter-city transportation problems. "The answer is probably to get people off the highways." Monorails also have some important disadvantages, say planners, including lack of esthetic appeal and high-speed capability.

● **Air-bearing approaches**—There is major interest in, and there is certain to be strong support for, some of the vehicles suspended with air-bearing techniques, either on the surface or beneath it. Scientists still do not know what the exact speed limitations of the wheel are, but they believe that for speeds above 200-mph, new frictionless systems will be required.

Systems categorized by Commerce officials as using aerodynamic suspension include ground-effects machines, low-pressure pads, and ram-air techniques. There are other air systems classed as pneumatic that include various air bellows and air piston suspension methods. There is also some interest in magnetic suspension systems, but less than there is in air bearings.

Ward reports that many approaches looked at thus far appear very favorable for either passenger or freight, but that a major factor in cost evaluation between competing designs will be the ability to combine the two services into a single system.

● **Tube networks**—Another area of research certain to get support is that of tunneling techniques. A breakthrough in development of an inexpensive means to tunnel for long distances at depths several hundred feet below ground will avoid enormously expensive right-of-way costs in the U.S. and would certainly strengthen proposals for tube-systems. Ward points out that the right-of-way costs associated with extending the new Boston Downtown Expressway were on the order of $40 million per mile. The right-of-way for the new 135-mph Japanese railroads reportedly cost on the order of $5 million per mile.

That same Japanese train also requires about two miles to come to a stop from high speed, and this represents another area Commerce officials say is sure to be researched. Dynamic braking schemes, those using friction or various retro-braking systems, are possibilities in addition to pressure systems for use with tube conveyances.

The Commerce Dept. will also look into stabilizers for vehicles, both active and passive systems that allow a vehicle moving at possibly 200-400 mph speeds to remain in a stable trim. The ability to do this effectively would mean that whatever form of roadbed the vehicle traveled over, it could be laid in an optimum fashion, taking full advantage of natural terrain, taking curves at high speed, and avoiding extensive roadbed banking.

Ward points out that banking for very-high-speed vehicles without stabilizers could be so severe that slower speed vehicles using the same roadbed or guideway could conceivably fall off a curve.

The propulsion area is tied closely to the form of suspension used and also opens many possibilities. Ward says there is need to look into: improved solid-state a-c electric motors; linear motor concepts in which the motor's stator is located in the vehicle and the rotor in the track; the so-called fan-in-the-tube concept for tunnel systems; turbojets with improved efficiency and low-noise qualities; fan-jets and by-pass engines. Ward also notes that some of this research could be applicable to V/STOL aircraft development.

He feels V/STOL aircraft will come into play in inter-city travel of the future, possibly as a means to bring passengers in from outlying areas to a high-speed ground-system terminal.

Any new ground system probably will employ computer control, which will enable a short headway to be maintained between vehicles, and will also allow optimization of the amount of service. Also envisioned is high-speed rendezvous between vehicles, allowing the removal or addition of cars at different cities without stopping the conveyance.

● **Designs not demanding**—Several aspects of design appear to offer no new technical challenges. Ward says structural requirements are within the current technology, as are microwave communications links and human factors considerations. Ward says past Defense Department, NASA, and industry work in these areas will be applicable.

Ward reports that there is need for something new in the area of handling material at terminals. He also feels that terminal design "can be improved by a few orders of magnitude," including use of automatic fare collection and baggage handling. Ward also sees a high payoff in adapting missile maintenance concepts of modularity and plug-in replacement to high-speed transport so that entire vehicles don't have to come out of service to have repairs made.

Managing such a system, if it is developed, will also require something new, although an organization patterned after the Communications Satellite Corp. is a possibility. It is in the systems development management area in particular that Ward feels "the aerospace industry has a background that no one else can equal. They don't have a lock on it," he says, "but they certainly have a head start."

The reaction to plans for the Northeast Corridor are varied. It represents a new market potential for aerospace firms. It also has an attraction for those who are today the backbone of the railroad business and who have shown a strong interest in moving into fabrication of new kinds of ground conveyances. Auto manufacturers, who would lose some sales because people chose other transportation, might also be expected to move heavily into some of the replacement manufacturing business. Some firms, such as Ford, have pioneered in the development of new ground-system concepts.

There is, however, most apprehension from the traditional passenger carriers. The bus lines, according to Commerce officials, have stated their misgivings. The airlines are apprehensive but have not said so publicly. The railroads are also concerned because they are not sure the system that evolves will have any resemblance to a traditional rail system. ■

Study Lab for Moon Explorations

THIS VEHICLE is a mobile geological laboratory, which is expected to contribute valuable scientific information for early American manned landings on the Moon. Built by General Motors Defense Research Laboratories for the U.S. Geological Survey and NASA, the eight-ton vehicle is shown doing preliminary testing in Southern California volcanic fields. Developers stress it is not a lunar vehicle prototype.

ETR Antenna Gets Wide-Range Ability

Modification of Pretoria equipment provides transitional link to full S-band operation; first step in range updating for future space missions

by Rex Pay

PALO ALTO, CALIF.—Modification of the 60-ft. AT-36 telemetry antenna at Pretoria, South Africa, to receive and autotrack at frequencies from 130 to 2,300 mc marks the beginning of the updating of the Eastern Test Range to handle spacecraft S-band telemetry.

To modify the antenna so that it will receive and track over such widely different frequencies, a hybrid technique is used in which a monopulse system simulates a conical mechanical scan.

This removes the rotating joint problems of a mechanical scan, and avoids the complexity of a conventional monopulse system.

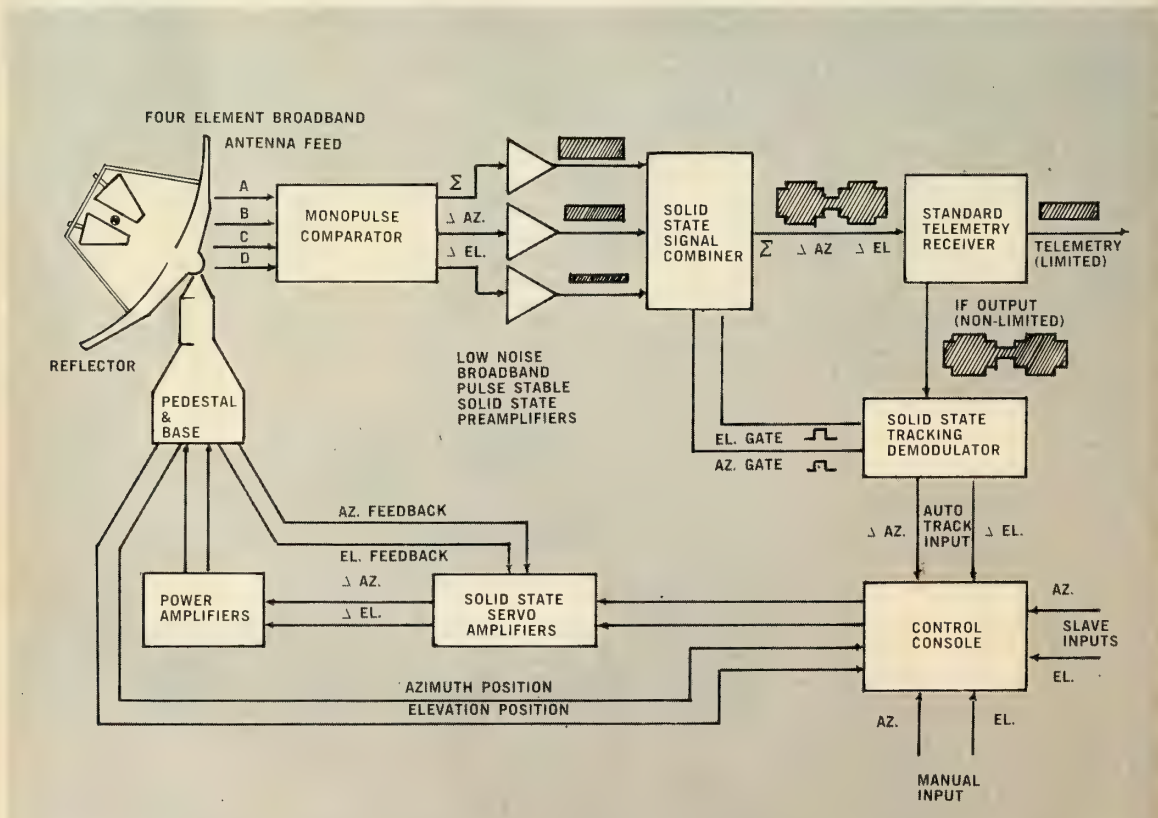
Updating of the antenna is being carried out by Astro Technology, Inc., under contract to the Air Force. The hybrid system has previously been applied by the firm to a 24-ft. antenna at the Naval Electronics Laboratory.

It is important that ground facilities be available to test new airborne S-band transmitters as they become available, and Astro Technology is aiming for a December completion date for the Pretoria antenna change.

● **Wide-band needed**—In the interim between now and conversion of spacecraft telemetry to full S-band operation, there is likely to be a considerable market for wide-band antenna systems. "I see a tremendous future for this type of feed system for the next five years," says Robert T. Smith, Chief Engineer of Astro Technology.

The new equipment associated with the antenna will cover the desired fre-

Astro Technology modified monopulse system being fitted to Pretoria station is broadband and simulates a conical scan.



quency range in two bands: 130-900 mc and 900-2,300 mc. Initially the lower band will only be implemented from 130 to 410 mc.

Developments that have made the broad-band telemetry and auto-track feature possible are traveling-wave-tube preamplifiers operating over octave bandwidths, and solid-state distributed amplifiers (developed for electronic reconnaissance), says Smith. He also notes that solid-state switches and very-broadband hybrid networks are other devices that have come forward in the past two years and made the antenna system feasible.

For the 900-2,300-mc band, a pre-amplifier using Watkins-Johnson TWT's will be installed. For the 130-410-mc band, a solid-state distributed amplifier will be used.

Specifications call for 0.1-degree static tracking accuracy. There will be a 0.1 to 0.2-degree shift due to frequency and polarization changes and the main servo system is such that a 0.2-degree dynamic error can be expected.

Antenna beamwidth is 9 degrees at 130 mc and 0.5 degrees at 2,300 mc.

● **Feed element construction**—The new feed system on the 60-ft. dish contains contra-helical wraps designed for right-hand and left-hand circular polarization. Feed elements for the lower band are welded from aluminum using typical shop techniques. For the high-frequency band, however, precision structual methods using photo-etch techniques are called for.

By combining error signals from a monopulse detector to form a simulated conical scan error signal, Astro Technology avoids the rigid gain and stability requirements of a full monopulse system.

The hybrid system does, however, share one inherent disadvantage with mechanical conical scanning. If the incoming telemetry carrier signal is amplitude-modulated at the conical scanning frequency, pointing errors can occur. Such modulation might be caused if the satellite generating the telemetry were tumbling. Fortunately, when this situation is recognized, the simulated conical scanning rate can be moved out of the frequency band of interference.

Signals from the antenna's four-element broadband feed-pass to a monopulse comparator to yield signal strength, elevation error and azimuth error information. These three channels then pass through solid-state pre-amplifiers, which set the noise figure of the system, to a solid-state signal combiner. This, in conjunction with a standard telemetry receiver, is used with a tracking demodulator to derive the autorack azimuth and elevation signals for the antenna servo system. ■

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GT-4 Crucial to Manned Flight Plans

Four-day mission will give U.S. scientists first chance to appraise effects of weightlessness; experiments detailed

by Heather M. David

THE UPCOMING *GEMINI* flight is the critical mission of the whole program, in the estimation of NASA's top medical authorities.

Dr. Charles Berry, chief of medical operations for manned spaceflight, told M/R that *GT-4* will determine the future of the *Gemini* and *Apollo* programs. While the original *Gemini* flight plan called for an increase to a full week mission in *GT-4,* Berry said he felt that he could not approve such a quantum jump in exposure to weightlessness.

The real evidence of danger, Berry pointed out, will not appear during the flight. Although an astronaut might appear to be perfectly healthy during a seven-day mission, he might be suffering irreparable damage to his body which would not be discovered until his return to gravity.

The four-day mission will offer the U.S. an opportunity to get, for the first time, fairly definitive data on the exact physiological effects of weightlessness. Instruments and experiments are designed to detect the subtlest signals of change. These readings will be compared with post-flight ground data, providing a basis for future predictive diagnoses in flight.

It is reported that no decision has been made as to whether one astronaut will open the hatch and expose at least his head and shoulders to real space. Although Berry indicated that there is scant time remaining in which to change the flight plan, there appears to be a fighting chance that this experiment will be moved up from *GT-5*. A version of the extravehicular suit is already scheduled for the flight, and the maneuver has been simulated in the *GT-4* capsule at McDonnell Aircraft Corp.

● **Cardiovascular**—Effect upon the circulatory system continues to be the prime concern of space agency physicians. The pooling of blood in the lower extremities, or "orthostatic hypotension," suffered by Walter Schirra and Gordon Cooper after their six- and 22-orbit flights indicated a "moderately deleterious" effect.

Because of this concern, tilt-table testing, which originally was planned as an experiment, has been incorporated into the regular medical operations procedure for all flights. Before the flight, baseline data on pulse rate and blood pressure will be determined by tilt-table test. This involves taking these measurements for one-minute intervals for five minutes before tilt, during a five-minute period in which the subject is on the tilted table, and for five minutes after tilting.

After the flight, the procedure will be repeated four times—immediately after egress, an hour, six hours, and 24 hours after the flight.

The experiment will indicate the body's ability to maintain normal circulation, blood, total body water and interstitial fluid volumes.

The first medical experiment to be performed in the *Gemini* program will be one which NASA designates M-3. Using a bungee cord, astronaut Edward White will periodically exercise to determine his capacity to perform physical work. Respiratory rates and blood pressures will be recorded before and after the exercise, which will require a 60-lb. pull per second for a predetermined period.

White also will be the subject of experiment M-4, in which his phonocardiogram will be recorded and compared with his electrocardiogram. This measurement, as suggested by Dr. Clarence M. Agress of the Cedars of Lebanon Hospital, may indicate any changes in the interval between the time an electrical signal is given to activate the heart, and when it actually contracts. A lengthened time interval would indicate fatigue or functional changes in the muscle.

The Soviets reported such an increase in heart action during longer flights, specifically in the QRS complex of the electrocardiogram onset of contraction of the ventricles.

The phonocardiogram, developed by Beckman Instruments, operates in much the same way as a doctor's stethoscope, transmitting heart sounds.

● **Bioinstrumentation**—As part of their regular medical monitoring equipment, both astronauts will wear in belts around their waists an instrument package developed by Spacelabs, Inc. Two sets of electrodes attached by thin leads will be placed upon the astronaut's chest. One set monitors ECG only, the other is shared by the impedance pneumograph.

Two electrocardiograph amplifiers detect the electrical signals, compensating for any adverse conditions by a high input impedance of more than 20 megohms each, side to ground, for each amplifier. Common mode rejection, Spacelabs engineers say, is greater than 100 decibels, even with a d-c offset at the amplifier input. Bandwidth is 0.2 to 100 cps.

The impedance pneumograph, also a Spacelabs development, operates with the chest electrodes excited by a 0.55-milliampere, 50-kc current source. Changes in the a-c impedance across the chest as the astronauts breathe are recorded in waveform reflecting rhythm and volume.

The Spacelabs oral temperature unit consists of a precision thermistor bead on the end of a thin, plastic-covered lead. Temperature is normally returned within 20 seconds maximum, with an accuracy within 0.1° within the range from 95° to 105°F.

The unit can be checked for accuracy during the flight by using a standard resistor producing a signal equivalent to 100°F. Deviations in calibration would be reported and taken into account in interpreting the output signal.

The blood-pressure cuff, developed by AiResearch Div. of Garrett Corp., works much like that used by a physician in his office. The inflatable cuff on the upper arm is pressurized by a manually-operated squeeze bulb. A piezoelectric microphone placed over the artery below the cuff picks up blood-pulse sounds as pressure is lowered.

The telemetered signal is mixed, containing both arm cuff pressure and pulse sounds. However, systolic and diastolic

values can be separated and extracted easily.

A miniature magnetic tape recorder developed by Cook Electric is used to record heart and respiratory signals during the flight, for playback after the mission for detail study.

● **Demineralization** — Another effect of weightlessness feared by medical men is loss of calcium from the bones and muscles. Although the Soviets have hinted at such a finding, there is no real documentation as to rate and onset of the problem. There is some dispute among U.S. physicians as to whether some of the serum analyses of the astronauts can be interpreted as showing a calcium mobilization effect.

A very precise X-ray technique has been developed by NASA for pre- and post-flight comparison of some of the small bones which might be expected to show a loss of density from calcium mobilization. These are the oscalcis (heel bone) and distal phalanx (end bone) of the right fifth finger. Both *GT-4* astronauts will be examined with the new technique. Difference in the amount of demineralization—if there is any—between pilot James A. McDivitt and co-pilot White will be compared to see if the exercise performed by White has a counteracting effect. ■

space medicine

Effects of Voskhod Flights Revealed

Soviets papers report some unusual physiological effects of flights, but no impairment of principal functions

SOVIET COSMONAUTS on the *Voskhod I* and *Voskhod II* spacecraft evidenced a number of unusual effects from their one-day spaceflights, including changes in blood chemistry, circulation and kidney function.

Although no evidence of disruption of principal functional systems was given, Soviet doctors O. G. Gazenko and A. A. Gyurdzhian said that preventive measures and training programs must be devised. Details were given in recent Soviet papers just translated.

A close look at the Soviet discussion on the extravehicular feat of A. Leonov shows that there has been some confusion in the popular press as to the difficulties encountered by the cosmonaut in maintaining his orientation outside the vehicle. Gazenko and Gyurdzhian said that both Leonov's report and biotelemetric data "gave no indications of any autonomic disturbances arising as a result of vestibular and optokinetic stimulation."

Although the Soviet doctors said that if the vehicle did not come into his view it was difficult to quickly determine the probable location of the craft, with proper visual orientation there should be no problem. "This . . . confirms the existing concepts of the physiological mechanisms of spatial analysis with interaction of the sensory organs."

● **Post-flight changes**—Crew members of *Voskhod I* showed "peculiar reactions" to functional cardiovascular tests 24 hours after the flight. Reaction to exercise was more pronounced, and restoration period was longer. Stroke and minute volume decreased by 26-47% in Yegorov and Feoktistov, and pulse pressure by 10-24 mm Hg. Yegorov also had a drop in arterial pressure after the functional test.

An increased cholesterol count also was noticed. The evening after the *Voskhod* flight, cholesterol count was 260-290 mg percent rather than the cosmonauts usual 120-180 mg percent. The next morning, the Soviet medics report, it was still 220-260, and it did not return to normal until two weeks later.

This was interpreted as signifying some strain on liquid metabolism arising during the flight, and indicated possibility of a fairly long residual effect.

Blood sugar also varied with individual cosmonauts. Yegorov had a low sugar concentration, where Komarov's was high. Although ratio excreted in the urine was not significantly abnormal, the Soviets point out that these were results of the 24-hour flight and that a more pronounced reaction probably would be found in longer flights.

Energy expenditure by Belyayev the day after the flight exceeded pre-flight value by 29%, while Leonov's exceeded it by 13%.

Kidney function, tested in Komarov and Yegorov by the water load method two days after the flight, indicated that water was eliminated more slowly than before or two weeks after. However, there were no indications of impaired glomerular filtration or concentration capacity of the kidneys.

Blood samples taken during the second and twelfth orbits of *Voskhod I* showed a slight increase in blood urea to 41-51 mg percent, compared with control samples of 40 mg percent. Soviet doctors saw this as indicating some intensification of protein decomposition during flight. A leukocytic condition also was developed by Yegorov, Gasenko said.

● **Inflight monitoring**—In general, cardiovascular and respiratory responses were somewhat less in *Voskhod* than in *Vostok* series flights. Cardiac rates of Belyayev and A. Leonov increased somewhat, accompanied by a fairly pronounced sinus tachycardio, just before the extravehicular maneuver, but these responses were expected from preflight training exercises.

Oculograms also showed a higher rate of eyeball movement during the first to fourth orbits. This might be attributable to the excitement of the extravehicular maneuver.

Biomedical monitoring of Leonov during the time he was outside the spacecraft was accomplished through the tether line, which contained electrical wiring for his equipment. The pilot, as well as ground monitors, were able to keep watch on Leonov's reactions. Although his pulse rate rose as high as 168 during the time he was trying to re-enter the lock, it quickly dropped to 100-120 after entering the spacecraft again, the doctors said.

Radiation exposure of *Voskhod II* cosmonauts was almost double that received by those in *Voskhod I*, since the apogee and perigee were higher (254/304 mi. compared with 143/205). Total dose received by both Belyayev and Leonov was 70 millirad, with no difference between the two in spite of the fact that Leonov was outside the cabin for a short interval. ■

'Pyrofuze' Finds Ordnance Application

Bimetal expands beyond original use in circuit-breaker field to become safe, versatile pyrotechnic substance

by John F. Judge

A BIMETALLIC MATERIAL—capable of being fabricated in virtually any shape—is being engineered for a host of ordnance and ignition applications by designers at Pyrofuze Corp., an affiliate of the Sigmund Cohn Corp.

Initially designed for use in the circuit-breaker field, Pyrofuze® is supplementing the state of the art in ordnance functions such as ignition, cable-cutting, stage separation, precision time delays, solid-propellant additives, thermal fusing and electrical fusing.

The material is easily handled and has all the design flexibility of wire or foil. In its foil form, the material is applicable to environmental enclosures such as diaphragms and closures for squibs and nozzles.

Frank Stevens, general manager of Pyrofuze Corp., says the material has many of the properties of a pyrotechnic without the usual drawbacks—especially in safety and reliability.

Physically, in any of its several forms, Pyrofuze has the appearance of a well-polished chrome- or silver-plated buffed surface. But with the application of a small amount of heat, the material reacts, providing a functioning temperature in excess of 2,800°C.

The "ignition" heat can be supplied through electrical resistance.

● **Composition**—Pyrofuze consists of palladium and aluminum in a bimetallic composite. Initiation takes place when this composite is brought to the melting point of the aluminum. An alloying reaction begins between the two materials when the aluminum melts, with a final violent exotherm that results in deflagration without support, or inclusion, of oxygen. The material is insensititve to shock, impact or vibration. Initiation is by heat alone.

Once the reaction has been triggered, it cannot be stopped until all available material is completely alloyed or massive mechanical cooling is instituted to bring the mass below its reaction temperature. Also, because of the nature of this reaction, Pyrofuze functions quite handily under environmental extremes.

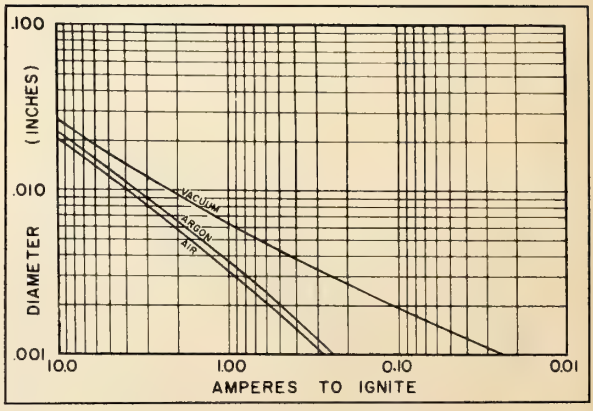
The prime early example of the application of Pyrofuze single-strand wire has been in the area of electrical fusing, particularly of the small-cartridge type. Two advantages of this material for fusing are its very sharp "blow" characteristics and the fact that after the wire functions, there is absolutely no chance of re-establishing contact between loose ends of the fuse wire.

The material has also been encapsulated completely for non-arcing construction. The transition from conventional cartridge fusing to inline fusing is relatively simple. In this case, a circuit designer, rather than incorporating a fuse block or a fuse-holding device, simply inserts a section of Pyrofuze wire of a measured length and diameter directly in the circuit. Again the sharp blow characteristics carry on into space applications for electrical fusing. However, the lack of heat-sinking in vacuum means that the fusing currents are somewhat lower than they would be under standard conditions.

A further ramification is electrical/

THRESHOLD ignition currents for various sizes of Hi-R Pyrofuze wire.

Diameter (Inches)	Milligrams per 20 CM	Calculated Resistance Ω/ft at 25°C	Amperes to Ignite — Air	Argon	Vac.
.020	300.0	0.155	9.50	8.80	6.50
.015	169.0	0.275	6.90	6.00	4.10
.012	108.0	0.430	5.00	4.40	2.80
.010	75.00	0.620	4.00	3.50	2.20
.009	61.00	0.760	3.50	3.00	1.80
.008	48.00	0.970	3.00	2.70	1.50
.007	36.60	1.26	2.60	2.20	1.20
.006	27.00	1.72	2.10	1.85	0.900
.005	18.80	2.50	1.70	1.50	0.650
.004	12.00	3.86	1.30	1.15	0.430
.003	6.75	6.90	0.95	0.80	0.250
.002	3.00	15.50	0.60	0.50	0.100
.0015	1.69	27.50	0.45	0.35	0.060
.001	0.75	62.00	0.30	0.25	0.020
.0009	0.61	76.00	0.26	0.23	0.018



thermal type of fusing in which the characteristics of a conventional fuse are desired. It also gives the additional safety factor of environmental overheating causing intentional interruptions of the circuitry. In such a situation, accidental overheating will cause the Pyrofuze reaction to take place and open the circuit. The results are essentially the same as those achieved with straight electrical fusing.

● **Bridging application**—Closely related to electrical fusing is the use of Pyrofuze wire as a bridge in pyrotechnic initiators, detonators, and other ordnance-initiating hardware. Because of the violent reaction that takes place when Pyrofuze is fused by the passing of electric current, the need for sensitive first-fire material has been eliminated in many cases of squib construction. The flash of the Pyrofuze wire itself during reaction is sufficient to ignite relatively insensitive compositions. Also, with Pyrofuze, it is possible to incorporate a degree of standoff between the bridge wire and initiating composition.

The recently introduced 1-amp, 1-watt, no-fire requirement has provided another application for Pyrofuze. Devices utilizing Pyrofuze bridge in the 1-amp, 1-watt, no-fire system are duplications of the conventional initiator hardware. With proper design, Stevens says, there is no sacrifice of functioning time in such devices even after passing this test.

There are some successful detonator configurations using Pyrofuze and RDX or PETN with no intermediates. Pyrofuze is detonated by means of the burning or deflagration-to-detonation.

● **Delay function**—A relatively simple electrical delay ignition system can be fabricated from Pyrofuze wire because of its very sharp and abrupt functioning point. By controlling the amount of current or the rate of current flowing into a given diameter of Pyrofuze wire, the functioning time of that piece of wire can be closely controlled. Delays ranging from submillisecond up to approximately one second can be pre-determined with accuracy by pre-programming time-current cycles.

Pyrofuze, singly or in combined forms, has been successfully used for propellant ignition systems. There is no igniter-produced gas pressure, even in very large quantities. Gasless reaction is necessary in systems in which initial igniter pressure is undesirable and only pure ignition is sought. The reaction temperature, in excess of 2,800°C, is more than adequate for igniting propellants. Such systems can be fabricated entirely from Pyrofuze, with no pyrotechnics or explosives. A typical design starts with a single strand of Pyrofuze wire as the original initiating "bridge," which in turn is led off into more massive forms of Pyrofuze having the final heat-producing ability for ignition. These ignition systems can be adapted to end-type ignition or through grain ignition with a minimum amount of difficulty and hardware complications.

Ignition systems can be made either instantaneous or programmed for delayed ignition. By the incorporation of Pyrofuze itself into the solid propellant when it is being cast, relatively simple pre-programming of the propellant burning rate can also be established. Such a motor can go from a boost phase to a cruise phase and back, thereby creating any number of combinations of time pressure curves, says Stevens.

Another area similar to electrical fusing is one-shot electrical switching. Very simple one-shot, normally open or normally closed switching devices have been devised. Circuits capable of carrying many amps of power can be opened or closed, using very small levels of triggering energy. But in the normally open configuration, the fused end products of the Pyrofuze reaction are used as the continuity link, and the circuit is essentially welded closed.

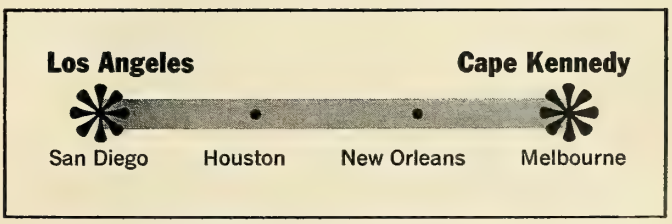
● **Precision delay**—A relatively new application for the material in its braided form is in precision time delays as a replacement for the normal pyrochemical type. The simplicity of such a system gives the delay-train designer significant flexibility. For the required length of time, an appropriate amount of braid is cut, and then, depending upon the final configuration, either placed in a protective covering or wrapped on an insulating mandrel. Delay trains may be initiated either from a percussion- or stab-type primer, from direct electrical initiation, or from a flame source such as a squib or the hot gasses from a rocket motor.

The protective sleeving is necessary to prevent jump ignition in some configurations, or possible damage to surrounding equipment caused by the short-lived hot metallic particles projected from the reacting braid. These projected particles have essentially low mass, are of very low velocity and are easily contained inside the lightest protective covering.

● **Structural shearing**—By combining the various forms of Pyrofuze, such as braid and foil, very simple shroud and reefing line cutters can be designed which are lightweight, easy in operation, and low in cost.

The mechanism in such an application is that of burning or melting rather than chopping or guillotining. This de-

What's the shortest distance between these 2 points?



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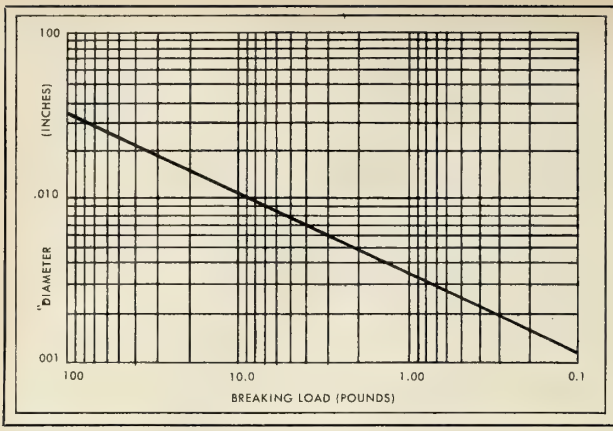


Wire Diameter (Inches)	Breaking Load (Pounds)	Wire Diameter (Inches)	Breaking Load (Pounds)
.001	0.09	.011	9.70
.002	0.33	.012	11.50
.003	0.70	.013	13.50
.004	1.25	.014	15.50
.005	1.90	.015	17.50
.006	2.80	.016	20.00
.007	4.00	.017	22.00
.008	5.00	.018	27.60
.009	6.40	.019	29.00
.010	8.00	.020	31.70

BREAKING loads for various sizes of Hi-R Pyrofuze wire.

sign concept has been extended to deflation systems for various inflated structures, ranging from complete and massive destruction to puncturing.

There are three general areas of application of Pyrofuze to separation devices. In the first, the material sustains the entire load. Initiation of such systems is either direct, electrical, or by external flame source. In such a system, Pyrofuze is usually applied as either a wrapping, supporting or binding medium utilizing either wire, braid, foil or combinations.

The next area might be considered as a combination pyrochemical-mechanical type of system in which, through mechanical linkages, the major portion of stresses and strains are experienced by high-tensile steel parts, and only a fraction of the total load is sustained by the Pyrofuze materials that act more like a simple locking or restraining member.

The final area of application is in the field of intentional structural failure. Here the material is combined in any one of several forms with high-strength aluminum alloys and several simple systems have been created. This latter group falls more in the hinge-pin, toggle-pin and restraining-pin family of separation units.

Further modifications of the foil form find applicability as total enclosures, such as rocket motor cases—exclusive of the nozzles—and other uses in which a container at the completion of a job or during a mission has to be completely destroyed, leaving a minimum of debris.

A final, relatively unsophisticated use of the varying forms of Pyrofuze is simply as a heat source. The material has functioned in this capacity where, for a number of reasons, conventional pyrotechnic or flame heat is undesirable. ■

advanced electronics

Practical Nanosecond Timer Developed

CONCORD, CALIF.—Eldorado Electronics has produced an electronic analogy of the machinist's vernier on which interpolations with a 2- or 3-place decimal accuracy can be made between graduations on parallel scales.

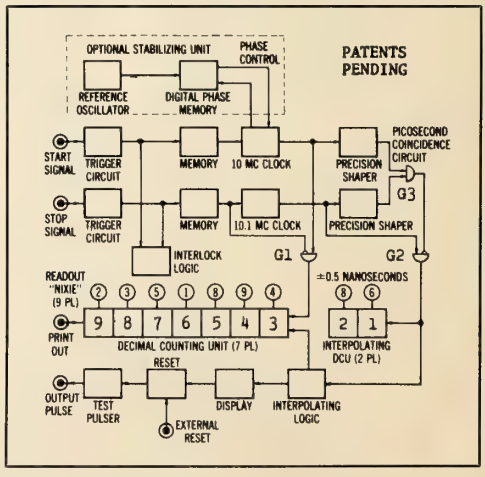
Using this technique, timing oscillators that would normally be expected to give tenth microsecond accuracy can be made to measure accurately to less than a thousandth of a microsecond.

This makes the nanosecond timer a very practical instrument, and the firm is attempting to break into the limited-war and commercial markets with it.

An integrated circuit version of the timer has been developed for backpack applications in conjunction with field radars or with laser rangers.

Commercial applications may include pulsed laser altimeters and automatic landing systems. Related military applications may be for helicopter altimeters in combat missions of the type flown in Viet Nam, and for terrain clearance radars. In such radars, the timer is valuable not only for the high-altitude resolution it provides but also for its capability to feed a digital computer directly.

● **Timing shorter intervals**—Although Eldorado has run into non-believers with its one-nanosecond counter, it is pushing toward instruments for timing even short-



BLOCK DIAGRAM of the Eldorado one-nanosecond time interval counter.

er intervals. The firm has a 0.5 nanosecond timer working and is currently considering development of one that can measure down.

The Type 5400 microminiature radar/laser range unit for field use provides five-meter resolution (the radar meter is 6.675 nanoseconds) over an operating range of 5 to 10,000 meters. Its circuits operate at 1/20 the frequency needed to achieve five-meter resolution with the traditional approach to counting. The circuits typically operate at 7.5 mc, well within the capability of current integrated circuits, making microminiaturization economical.

The unit has a volume of 15 cu. in. and weighs 10 oz. Range display is by means of in-line Nixie tubes, which add 10 cu. in. to the volume.

Absolute accuracy is specified as resolution ± oscillator stability ± gate error. Normal velocity of propagation is assumed, but errors up to one part in 10,000 can be encountered under some conditions. Resolution is ± 2.5 meters, oscillator stability is ± 1.5 ppm/°C and gate error is ± 1.5 meters.

● **Other models**—A larger-sized unit, the Model 5210, provides ± 0.5 ft. accuracy, 1 ft. quantizing resolution, adjustable range gate, and multiple target selection. Operating range is 1 ft. to 10,000 ft. The operator can select any one of the first three target returns on which he wishes to make a range measurement. He can also reject all targets out to 100, 400, 1,000, 4,000, or 10,000 ft. by resetting the range switch.

In this unit, the interpolation technique enables two-nanosecond time intervals to be measured with a counting circuit that operates at only 5 mc. This is 1/100 of the frequency needed to achieve this resolution with the traditional approach to counting.

A somewhat different function is provided by the Model 6003 radar range unit, designed to upgrade installed radar equipment. It enables an operator to obtain direct digital range and bearing by pointing at a target on a PPI display with a light probe. Specifically designed for the AN/SPS-5 radar set, the unit provides range to 10,000 yds. in 1-yd. increments and bearing in 0.1-degree increments for direct input to a digital computer.

For one-nanosecond time interval measurement, Eldorado has developed the Model 793, which has ± 0.5-nanosecond accuracy without the customary ± 1-count digital error.

As in conventional timers, the 793 uses an accurate oscillator that starts at the beginning of the period to be timed and stops at its end, the number of cycles occurring during the interval indicating the time period. Special features of the 793 are use of two oscillators capable of starting up within picoseconds, and a picosecond coincidence circuit. The normal ± 1-count digital error is avoided by phase-locked memories in the start and stop channels.

When a signal arrives at the start-channel input, a 10-mc clock provides 100-nanosecond clock signals that are precisely phase-locked to the start signal. These signals are totalled on the hundreds and higher decades of the instrument's decimal counting circuits. No information is fed to the tens- and units-counting circuits until receipt of the stop signal.

When the stop signal arrives, it cuts off the 10.0-mc clock pulses from the counting circuits where they were totalled and simultaneously phase locks a 10.1-mc stop-channel clock. The 99-nanosecond pulses from this clock pass through a second gate to the units- and tens-counting circuit until the picosecond coincidence circuit senses coincidence between the 10.0-mc and 10.1-mc signals.

At this time, the 10.1 clock pulses are inhibited, and this leaves the nanosecond vernier interpolation on display. ■

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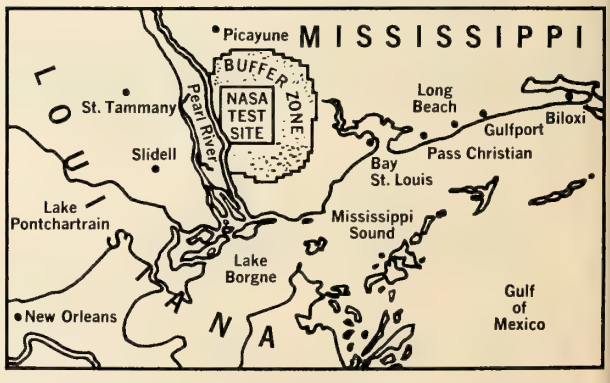


The Industry Week

Mergers and Acquisitions

General Precision, Inc., Tarrytown, N.Y., has purchased the business of the Riverdale, Md., plant of the Electronics Div. of ACF Industries, Inc. At the same time GPI made arrangements to lease the ACF plant. ACF's Riverdale plant engineers, manufactures and sells specialized electronics equipment and provides field, modification and repair services. The purchase did not affect ACF's other electronics facilities at Bladensburg, Md., and Paramus, N.J. . . . *Microdot, Inc., South Pasadena, Calif., has acquired Lincoln Dynamics, Inc., of Los Angeles and merged it with its Magnetics Div. Lincoln makes solid-state static converters and frequency changers. It will be operated as a wholly owned subsidiary under the name Microdot Magnetics, Inc.* . . . United Computer Co., Phoenix, Ariz., has acquired the Robotomics Research Facility from Textron Electronics. Inc. Robotomics makes decade counters and numerical displays, which will continue to be sold under the United Computer Co. name.

New Activities

Texas Instruments' Apparatus Div. has announced plans to divide its Electronic and Optical Systems department into two departments in a move to "concentrate technical and management capabilities in two important areas of corporate strength." Infrared and optical products will remain in the existing department, but a newly created Airborne Radar Systems department will concentrate efforts on lightweight radar sensors for low-altitude flight, tactical targeting and navigation. . . . *Vanadium-Alloys Steel Corp., Latrobe, Pa., has changed its name to Vasco Metals Corp. Vasco specializes in the production of tool steel, but also produces such non-ferrous and refractory-type materials as titanium tantalum, columbium, beryllium, vanadium, hafnium and zirconium. It also produces nickel and cobalt-base alloys.* . . .

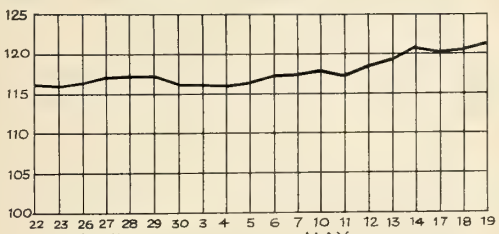
Facility Expansions

Hughes Aircraft Co. is expected to file an application this month to build a communications satellite research and test station near Hot Springs, Ark. The proposed station will consist of an 85-ft.-dia. antenna, transmitter and receiver facilities, and housing for equipment and personnel. . . . *The Hamilton Watch Co.'s Precision Metals Div. has put into operation in Lancaster, Pa., a fully integrated ultra-specialty metalworking plant. The new $1.5-million facility will be used to process a broad range of pure metals and alloys into ultra-thin strip and foils for use in the aerospace, electronics, nucleonics and allied fields.* . . . Memorex Corp., Santa Clara, Calif., a manufacturer of precision magnetic tapes, has acquired a 16-acre site adjacent to its present headquarters and plant for use in future expansion. . . . *Sperry Rand Corp.'s UNIVAC Div. is adding 47,000 sq. ft. to its St. Paul, Minn., plants. The space is expected to be used in meeting requirements of increased business of the UNIVAC Defense Systems Div. It will be used to accommodate expanded manufacturing and engineering activities and increased office facilities.* . . . Lenox Instrument Co., Philadelphia, has moved its plant and office to a new building that will provide nearly three times the space available in the old location. . . . *Branson Instruments, Inc., Stamford, Conn., has announced plans to move to a new 100,000-sq.-ft., two-story building. The new facility will house executive offices, and consolidate the manufacturing of ultrasonic thickness testing, and flaw detection, cleaning and harness testing equipment presently performed at two Stamford plants.* . . . The Refractomet Div. of Universal-Cyclops Steel Corp., Bridgeville, Pa., has completed the installation of a new 3,000° F vacuum annealing furnace. The furnace is designed for annealing all reactive, refractory and other metals requiring vacuum annealing treatments. The facility will be available for custom vacuum annealing on a conversion basis.

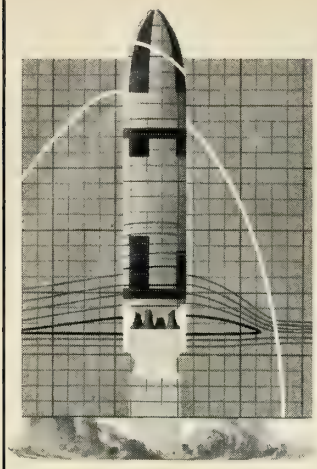
International

Airpax Electronics, Inc., Fort Lauderdale, Fla., and Le Prototype Mecanique, L'Etang-La-Ville, France, have agreed to a unique exchange of product manufacturing rights on the French firm's UGON relay and Airpax's miniature circuit breaker. The UGON, an extremely sensitive non-polorized relay that occupies only 2 cu. cm. of space, will be manufactured in the U.S. by Airpax, using tooling assistance from the French company. In turn, Le Prototype Mecanique's factory, employing technical aid and tooling help from Airpax, will manufacture the Airpax all-magnetic miniature circuit breaker. . . . *TRW, Inc., has purchased substantially all the shares of Cam Gears, Ltd., a supplier of steering components for the British automotive industry. Cam Gears is located in Hitchin, England.* . . . North American Aviation S.A., European subsidiary of North American Aviation, Inc., has opened three new regional offices in London, Paris and Bonn.

Missile/Space Stock Index



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH



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AERODYNAMICS—Rarefied and continuum aerodynamics, gas dynamics, hydrodynamics and external fluid dynamics, engineering mechanics.

STRUCTURAL DYNAMICS—Basic loads, environments, structural criteria, aero-elasticity, shock, vibration, acoustics, and structural feedback functions for analysis of controls stability.

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AWARDS

AIR FORCE

$6,500,000—**The Boeing Co.,** Seattle, initial segment of $80 million for ground equipment for Minuteman II ICBM.

$3,764,600—**Sperry Rand Corp.,** Great Neck, N.Y., for continued production of radar altimeter systems.

$3,000,000—**Perkin-Elmer Corp.,** Norwalk, Conn., first installment on a $9-million contract to manufacture aerial camera systems.

$2,948,455—**National Co.,** Mekose, Mass., for communications equipment.

$1,910,000—**Martin Marietta Corp.,** Denver, Colo., for work on *Titan II* missiles.

$1,700,000—**Avco Corp.,** Wilmington, Mass., for continued work on Minuteman missile re-entry vehicles.

$1,480,537—**Cornell University,** Ithaca, N.Y., for continuation of research in ionospheric physics.

$1,189,859—**Raytheon Co.,** Waltham, Mass., for research and development work on miniature communications equipment.

$1,104,820—**Litton Industries Inc.,** San Carlos, Calif., for research and development work on miniature communications equipment.

$1,008,322—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for continued work on *Agena* rocket boosters.

$996,588—**Rand Corp.,** Santa Monica, Calif., for aerospace research services.

$229,921—**Adcole Corp.,** Waltham, Mass., for research for design, development and construction of electronic instrumentation for ionospheric and extreme ultraviolet solar radiation measurements.

$142,855—**Simpson Gumpertz and Heger, Inc.,** Cambridge, Mass., for administrative and engineering service to accomplish structural analysis and engineering design evaluation of Mark 1 aerospace environmental chamber.

$98,944—**Lockheed Aircraft Corp.,** Lockheed Electronics Co., Div., Clark, N.J., for field measurements for the research and analysis of electro-physical effects of rocket launches.

$89,239—**Stanford Research Institute,** Menlo Park, Calif., for research on response of burning propellant surface to erosive transients.

$81,975—**Block Engineering, Inc.,** Cambridge, Mass., for engineering services in connection with Air Force Cambridge Research Laboratories instrumentation being flown aboard an ICBM nose cone.

$55,190—**Arthur D. Little, Inc.,** Cambridge, Mass., for continuation of research on recirculation in liquid rocket engines.

$48,400—**Astrosystems International,** Fairfield, N.J., for monitoring of rocket engine performance by spectroscopic techniques.

$44,183—**Dynamic Science,** Monrovia, Calif., for research on propellant sprays in liquid rocket engines.

ARMY

$15,000,000—**HRB-Singer, Inc.,** State College, Pa., for production of airborne infrared surveillance equipment.

$11,063,752—**Martin Marietta Corp.,** Orlando Div., Orlando, Fla., for research and development on a combat communications system.

$8,500,000—**General Electric Co.,** Missile and Armament Dept., Burlington, Vt., to produce gun pods for the Vulcan 20-mm weapon system.

$1,600,000—**Smith and Sapp Construction Co.,** Orlando, Fla., for alternations to two spacecraft buildings at Cape Kennedy.

$1,508,800—**Bulova Watch Co.,** Flushing, N.Y., to manufacture rocket-ammunition fuzes.

$1,291,648—**Arvin Industries, Inc.,** Columbus, Ind., for coder equipment components.

$1,000,000—**Western Electric Co.,** Teletype Corp., Skokie, Ill., for production of classified electronic equipment.

$1,000,000—**Space General Corp.,** El Monte, Calif., for advanced development of a device to detect biological warfare agents.

NAVY

$39,841,755—**General Dynamics Corp.,** Electric Boat Div., Quincy, Mass., for a new submarine tender designed as a mother ship for nuclear attack submarines.

$4,552,278—**Hughes Aircraft Co.,** Fullerton, Calif., first segment of an $18 million contract for work on a tactical data system.

$2,667,225—**Aerojet-General Corp.,** Sacramento, Calif., for rocket motors and igniters for *Tartar* missiles.

$2,020,700—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for continued research and development work for the *Polaris* program.

$1,464,320—**Textron, Inc.,** Grants Pass, Ore., to build telemetric data transmitting sets.

$1,168,505—**Otis Elevator Co.,** Brooklyn, N.Y., for production of sonobuoys for ASW.

$610,178—**Cook Electric Co.,** Cook Research Laboratories, Morton Grove, Ill., for research and development of counter-countermeasures.

$308,237—**General Instrument Corp.,** Westwood, Mass., for design improvement program for the *Polaris* sonar array.

$224,000—**Martin Co.,** Orlando, Fla., for field services, in-plant sevices and allied weapon system support for *Bullpup* system.

$85,420—**Douglas Aircraft Co.,** Santa Monica, Calif., for research directed toward optimization of structural components for hypersonic guided missiles.

NASA

$15,000,000—**Grumman Aircraft Engineering Corp.** Bethpage, N.Y., to build a fourth orbiting astronautical observatory.

$800,000—**North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., for mapping and survey systems, *Apollo* spacecraft and interface definition.

$757,000—**Electro-Mechanical Research, Inc.,** College Park, Md., for integration of two *Interplanetary Monitoring Platform* satellites.

$674,000—**Varian Associates,** Palo Alto, Calif., for precision atomic frequency sources to be used in the *Apollo* program.

$256,000—**Radiation Systems, Inc.,** Alexandria, Va., to build eight additional command antenna arrays for installation at tracking sites around the world.

$250,114—**Aircraft Armaments,** Cockeysville, Md., for *Apollo* crew station gondola.

$227,366—**Trans-Sonics, Inc.,** Burlington, Mass., for the development and fabrication of a digital measuring system.

$194,332—**Rocket Research Corp.,** Seattle, for study and development of an experimental hydrazine auxiliary rocket engine.

$157,000—**Feldman Bros., Co.,** Cleveland, Ohio, for installation of accelerator, decelerator and associated piping for the zero-gravity research facility at Lewis Research Center.

$147,000—**Perkin-Elmer Corp.,** Norwalk, Conn., for optical technology experiments for a satellite.

$94,754—**American Cyanamid Co.,** Wayne, N. J., for development of high-performance lightweight electrodes for hydrogen-oxygen fuel cells.

$42,157—**Honeywell, Inc.,** Research Center, Hopkins, Conn., for study of the interactions of magnetic materials.

Valpey-Fisher Corp., Holliston, Mass., for sterilized high-impact quartz crystal frequency control units (amount not disclosed).

Lockheed Aircraft Corp., Lockheed Aircraft Service Co., Ontario, Calif., for calibration, repair and maintenance of electrical and electronic test equipment at the Jet Propulsion Laboratory for one year (amount not disclosed).

INDUSTRY

$3,219,614—**Burroughs Corp.,** Detroit, from **Martin Marietta Corp.,** Orlando Div., Orlando Fla., to provide digital computers for the *Pershing* missile program.

$2,000,000—**Blaw-Knox Co.,** Equipment Div., Pittsburgh, from **Koppers Co., Inc.,** Malan Dept., Baltimore, to construct three flame deflectors for static test stands at NASA's Mississippi Test Facility.

$750,000—**Space Craft Inc.,** Huntsville, Ala., from **Sperry Rand Corp.,** Space Support Div., Huntsville, for the design, fabrication and test of welded electronic circuits to be used in support of the *Saturn I, IB* and *V* rocket research and development programs.

$220,468—**Fanstell Metallurgical Corp.,** Airtek Div., Compton, Calif., from **Hughes Aircraft Co.,** Fullerton, Calif., for flight hardware for *Surveyor* program.

$170,000—**Willamette Iron and Steel Co.,** Portland, Ore., from **The Boeing Co.,** Seattle, to supply a lock housing for the mechanism used to actuate and lock *Minuteman* silo lids.

$125,000—**Gerber Scientific Inst. Co.,** Hartford, Conn., from **Lockheed Aircraft Corp.,** Lockheed-Georgia Co., Marietta, Ga., for numerically controlled drafting line plotters to be used for drawings on all projects produced at the aerospace plant in Marietta.

$95,000—**Panhandle Aviation, Inc.,** Omaha, Neb., from **The Boeing Co.,** Seattle, to provide air transportation services during installation of Air Force *Minuteman* missiles in North Dakota.

$74,618—**Auto-Control Laboratories, Inc.,** Los Angeles, from **Hughes Aircraft Co.,** Culver City, Calif., for temperature vibration chambers.

Gesellschaft fuer Linde's Eismaschinen, A.G., Munich, West Germany, from **Chemetron Corp.,** National Cylinder Gas Div., Chicago, for an air separation plant supplying gaseous and liquid oxygen (amount not disclosed).

Goodyear Aerospace Corp., Akron, Ohio, from **Sundstrand Aviation,** Denver, Colo., for the design of a 52-ft.-dia., petal-shaped solar energy collector for space applications (amount not disclosed).

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

U.S. Army Missile Command
Redstone Arsenal
Alabama 35809

Design and development work for the *Hawk* ATB/HIP program to be awarded to Raytheon Co. Those interested in subcontracting opportunities should make direct contact with the company.

Purchasing Office
Range Engineering Procurement Div.
Air Force Eastern Test Range
Patrick AFB, Florida

Request for Technical Proposal PR 66-1023, due June 21, 1965, for the design, fabrication and test of focus calibration system for optical tracking instruments.

National Aeronautics and Space Administration
Headquarters
Contracts Division
Washington, D.C. 20546

Negotiations are being conducted with GCA Corp., for studies on the meteorology of Mars, Venus and Jupiter. RFP not available; for information only.

National Aeronautics and Space Administration
Headquarters
Contracts Division
Washington, D.C. 20546

NASA is negotiating with American Science and Engineering Inc. for a program of X-ray astronomy from sounding rockets. RFP not available; for information only.

John F. Kennedy Space Center
Cocoa Beach
Florida 32931

RFP Q-18-5, issued May 19 and due 21 calendar days from that time, for a study of contamination sensor as applicable to ground support equipment. When requesting bid set, provide information as to whether your organization is a large or small business. Evaluation factors include experience and knowldege in the field of contamination control and the availability of qualified personnel.

Manned Spacecraft Center
Gemini Flight Support Procurement Section
Houston, Texas 77058

RFP BG641-75-5-32P, due June 4, 1965, for a study on degradation effects of a space environment and re-entry conditions on parachute materials.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

NASA is negotiating with the University of Minnesota for a study of solid-propellant combustion quenching processes during pressure transients on a sole source basis. For information only; RFP not available.

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New Product of the Week: Adiabatic Calorimeter

An automatic quantitative adiabatic calorimeter for quantitative thermal analysis of unknown specimens over a wide temperature range is being marketed by Dynatech Corp.

The Model QTA-N7-ER measures samples 2½x2½x⅛ to ⅜ in. and weighing 25 to 100 grams. Accuracy of ±2% is achieved at temperatures from −300° to 200°F and of ±5% from 200° to 700°F.

In a single test setup, the device can determine the temperature at which transitions or reactions occur, whether these transitions are exothermic or endothermic; a quantitative measurement of the heat of reaction and specific heat as a function of temperature. The heat dissipated in a sample of known mass is automatically plotted as sample enthalpy increase versus sample temperature. The slope of this curve, modified with appropriate constants for geometric considerations, is the specific heat. At a transition point, the curve shifts either up or to the side, depending on whether an exotherm or endotherm has occurred. The magnitude of the shift and the magnitude of the heat effect is directly measurable on the plot.

Standard features include: a strip-chart recorder with five temperature scales; automatic control of shut-off temperatures; an automatic 32°F thermocouple reference junction; a voltage-regulated d-c power supply with a regulation of ±0.5%; and a mechanically pumped vacuum system capable of producing a vacuum of 10^{-2} mm. Hg.

Circle No. 151 on Subscriber Service Card

Time Delay Relays

A series of knob-adjustable electronic time delay relays, designed specifically for industrial applications, is available from the A. W. Haydon Co.

Circuitry is solid-state and load output is provided through a subminiature relay. The K31601 series has an input of 115v ac, 60 cycles; the K31602 line has an input of 22-30v dc. All units have a contact (DPDT) rating of 10 amps resistive and 5 amps inductive at 28v dc or 110v ac, 60 cps. Delay ranges are 0.1-10 secs., and 0.4-40 secs., and 4-400 secs.

Circle No. 152 on Subscriber Service Card

Microphone-Amplifier

A noise-cancelling dynamic microphone with a built-in transistor amplifier, designed for use in telephone-type handsets, is being marketed by Altec Lansing, a subsidiary of LTV Ling Altec, Inc.

The Model 697A is designed as a replacement for the carbon transmitter in G1-type handsets or their equivalent. It provides a frequency response of 100 to 5,000 cps. The device is encased in non-conductive material and weighs 1.5 oz. and measures 1 13/16 in. in diameter by 1 in. high.

According to developers, the transistor amplifier of the microphone assembly operates from the current normally supplied to the carbon transmitter and serves to raise the dynamic microphone output to that of the carbon element. By using less current than the standard carbon unit, an increase in loop length between the unit and the supply voltage source is possble.

Circle No. 153 on Subscriber Service Card

Leak Detector

Devco Engineering, Inc., is marketing a halogen leak detector for testing of tanks, piping and pneumatic systems.

The unit is capable of detecting freon, carbon tetrachloride, trichlorethylene or any other halogenated hydrocarbon at leakage rates as low as 1/50 ounce per year. The device is portable and is furnished with visual or visual/audible indication.

Circle No. 154 on Subscriber Service Card

Frequency Extender

Communication Electronics, Inc., has introduced a frequency extender, the Model FE-103, for use with VHF receivers.

The device tunes from 10 to 30 mc in a single band, converting signals to a 60-mc IF acceptable by CEI series 900 or other VHF receivers. Each megacycle spans almost 1.5 in. on the dial tape, which has a total length of 28 in.

The solid-state unit features a 2-mc bandwidth. Specifications include a maximum noise figure of 6.5 db, image rejection of 50 db or better and IF rejection of at least 40 db. Local oscillator radiation is a maximum of 20 microvolts. Dimensions are 3.5x19x15.5 in. It operates from 115/230v, 50-400 cps, 4 watts.

Circle No. 155 on Subscriber Service Card

Gas Regulators

A line of gas regulators specially designed for high-pressure service, such as ground support equipment applications, has been announced by Union Carbide Corp's Linde Div.

Designated the Oxweld R-8900 series, the regulators are available with delivery pressure ranges of 0 to 500 psi, 0 to 1,000 psi and 0 to 2,000 psi. One feature of the regulators is a cold me-

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chanical joining technique which permits connectors to be easily removed with a wrench. Use of neoprene diaphragms and nylon valve seats provides increased instrument sensitivity and rules out possible high-pressure leakage, the firm says.

Circle No. 156 on Subscriber Service Card

Silicon Power Switch

Texas Instruments, Inc., is marketing a high-gain silicon power switch that features two transistors in a Darlington configuration and a protective rectifier in a single monolithic structure.

The device, typed 2N3836-2N3837, has a gain of 2,000 minimum at 2 amps. Switching capability is t_{ON}=0.4 microsecs., t_{OFF} = 1.0 microsec. maximum at 2 amps. Power dissipation rating is 25 watts at 25°C case temperature. Collector current is 7 amps maximum; collector-emitter voltage is 60 to 80v.

Circle No. 157 on Subscriber Service Card

Slotted Section

A coaxial slotted section for determining efficiencies of RF transmission lines and components is available from Microlab/FXR.

The Model N115A is the latest in the firm's 115 series of slotted sections and is machined from a solid block of aluminum alloy. The broadband capability of the device provides measurements over a frequency range of 2 to 12.4 gc, which normally requires two or more instruments, the firm said. The slot is 0.1 in. wide and tapered at both ends. Maximum residual VSWR is 1.04 from 2 to 8 gc, 1.06 from 8 to 10 gc and 1.1 from 10 to 12.4 gc. Insertion length is 9.8 in. Weight is 4 lbs.

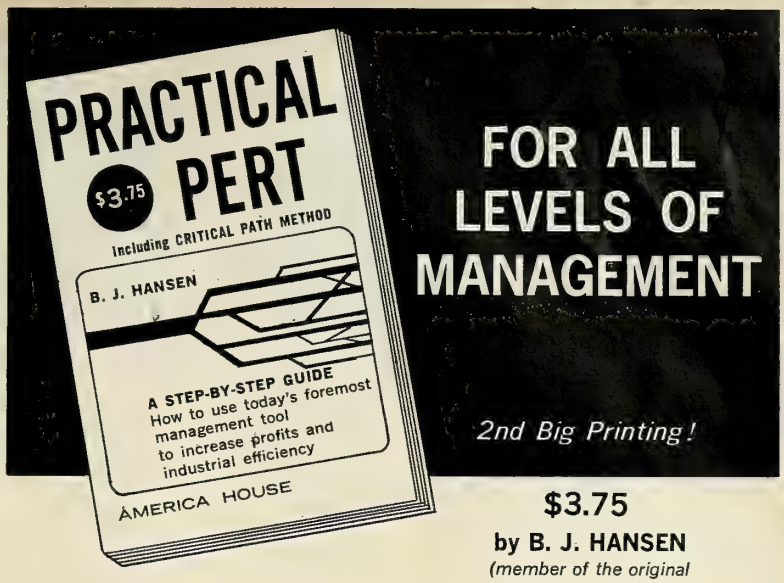
Circle No. 158 on Subscriber Service Card

Extreme Pressure Grease

Dow Corning Corp. is marketing a multi-purpose, extreme pressure grease, Molykote BR2-S.

The grease is an improved formulation based on the firm's Molykote BR2. It has a lithium soap base fortified with small-particle-size MoS_2 powder. According to developers, it can be used to replace a variety of special greases formerly considered necessary for difficult lubrication problems. It prevents wear by coating bearing surfaces with an almost indestructible solid film of molybdenum disulfide. The grease is said to afford excellent corrosion resistance under wet or humid conditions. Service temperature range is from —18° to 300°F and up to 350°F for short periods.

Circle No. 159 on Subscriber Service Card



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IV HOW PERT PLANS
V HOW PERT CONTROLS
VI BUILDING PERT
VII WHAT IS NETWORKING
VIII REFINING THE NETWORK
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HESS

POWELL

Charles B. Thompson: Appointed chief of project management office, Electronics Systems Div. of Brown Engineering Co.

Robert H. Wehrenberg: Named a vice president of Cleveland Pneumatic Tool Co., a subsidiary of Pneumo Dynamics Corp. He will continue as assistant general manager of CPT.

Charles H. Leithauser: Promoted to vice president of administration for the Martin Co. He was formerly executive director of administration.

Robert L. Ashley: Appointed vice president of marketing for TRW Electronics. Co. He was formerly executive director of Silicon Transistor Corp.

Robert W. Hess: Appointed general manager of Thiokol Chemical Corp.'s Panelyte Industrial Div.

Richard W. Powell: Joined Electro-Optical Systems, Inc., as manager of reconnaissance and intelligence programs. He will be responsible for identifying and coordinating long-range technical development goals and strategic business planning for reconnaissance and intelligence systems.

Ervin M. Bradburd: Appointed manager of the Communications Systems Laboratory of RCA's Defense Electronic Products, Communications Systems Div. Also appointed to new positions within the division were **William B. Kirkpatrick** as manager of business planning, and **Alfred W. Kupferschmid** as manager of product assurance.

Murry V. Jennings: Named vice president and director of public relations for American Gas and Chemicals, Inc.

Roy E. Wendell: Appointed manager of public information for Sperry Gyroscope Co., division of Sperry Rand Corp. Also named was **Herbert Harris,** as program manager to direct Sperry's integrated proposal effort for the Air Force's *SRAM* missile system. He is director of engineering.

Dr. Robert C. Langford: Named to head guidance and control research operations at NASA's Electronics Research Center. He was formerly director of the Aerospace Research Center of General Precision, Inc. NASA also named **Francis J. Sullivan** as director of the Electronics and Control Div. within the Office of Advanced Research and Technology. He will be responsible for research into all aspects of electronics and control systems.

John Sodolski: Appointed assistant to the vice president of the Electronic Industries Assn.'s Government Products Div. He will continue as manager of the Requirements Committee at EIA.

L. Arthur Hoyt: Named manager of publicity for Electronic Associates, Inc.

Raymond R. Kondrat: Named manager of marketing for metallurgical products of Metals and Controls Inc., corporate division of Texas Instruments Inc.

Conrad Young: Appointed director of communications marketing in the Communications and Electronics Div. of Philco Corp.

Dr. John W. Evans: Received the Department of Defense Distinguished Civilian Service Award, highest honor given a civilian employee of DOD, for his work in insuring safety for astronauts from the Sun's volatile emissions. He is director of the Sacramento Peak Solar Observatory (N.M.), part of the Air Force Office of Aerospace Research.

Glen Bayless: Appointed director of public relations for the Aerospace Industries Assn. He was formerly managing editor of the Washington Bureau for *Business Week* and other McGraw-Hill publications.

Arthur L. Chapman: Elected to the board of directors of the Hallicrafters Co. He is also executive vice president and general manager of the company.

Gen. Thomas S. Power (USAF-Ret.): Elected to the Houston Fearless Corp.'s board of directors.

Harlow J. Reed: Appointed executive vice president for metals within Olin Mathieson Chemical Corp. He was previously vice president for production and engineering.

Chester E. Le Roy: Elected a vice president of Fansteel Metallurgical Corp., as was **Frederick F. Fletcher.** Le Roy will continue to serve as general manager of the Metals Div., and Fletcher will continue as general manager of the Fansteel/Astro-Nuclear Group.

George J. Becker, Jr.: Became public relations manager of Ryan Aeronautical Co.

Charles P. Covino: Awarded the Grand Cross of the Eloy Alfaro Foundation of Panama for his personal and professional contribution of techniques, products and processes to improve structural and component reliability in air, land, sea and space vehicles. He is president of General Magnaplate Corp.

Richard Surbeck: Named general manager of the International Div. of Fairchild Camera and Instrument Corp.

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Administration of Government Contracts, sponsored by the National Defense Education Institute, Williamsburg, Va., May 24-28.

International Federation for Information Processing Congress and INTERDATA 65, New York Hilton Hotel, New York City, May 24-29.

Space Electronics Symposium, sponsored by the Aerospace Electrical Society and the American Astronautical Society, International Hotel, Los Angeles, May 25-27.

19th Annual Armed Forces Communications and Electronics Assn. Convention and Exhibition, Sheraton Park Hotel, Washington, D.C., May 25-27.

Second Aerospace Expandable Structures Conference, sponsored by the Air Force Aero Propulsion Laboratory and Archer Daniels Midland Co., Radisson Hotel, Minneapolis, May 25-27.

Seminar on Fluid Power Standards, sponsored by the Milwaukee School of Engineering, Fluid Power Institute and the Fluid Power Society, Allen-Bradley Hall of Science, Milwaukee, May 26.

First Joint International Symposium on Analysis Instrumentation and Chemical and Petroleum Instrumentation, sponsored by the Instrument Society of America, Sheraton-Mt. Royal Hotel, Montreal, Canada, May 26-28.

St. Louis Bicentennial Space Symposium and Fifth National Conference on the Peaceful Uses of Space, sponsored by NASA and the St. Louis Bicentennial Commission, Chase-Park Plaza Hotel, St. Louis, Mo., May 26-28.

Fourth Annual Management Conference on Marketing in the Defense Industries, sponsored by the American Marketing Assn. and Boston College, Boston College, Boston, May 27.

World Meteorological Organization Meeting, Geneva, Switzerland, May 27-June 11.

JUNE

International Symposium on Global Communications (GLOBECOM VII), sponsored by the University of Colorado and National Bureau of Standards, Boulder, Colo., June 7-9.

Propulsion Joint Specialist Conference, sponsored by the American Institute of Aeronautics and Astronautics, Air Force Academy, Colorado Springs, Colo., June 14-18.

Tenth Anniversary Scientific Seminar, sponsored by the Air Force Office of Scientific Research in cooperation with the University of New Mexico and the Air Force Missile Development Center, Cloudcroft, N.M., June 14-25.

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Give Them the Tools

THE THRUST OF RECENT EVENTS in Viet Nam and the Dominican Republic has brought home forcibly a point which Dept. of Defense officials have been trying to make for some time.

That is the need for application of the advanced technology of the missile and space programs to the needs of conventional or limited warfare.

We can strike out accurately through space to Mars or the Moon. We can send intercontinental ballistic missiles hurtling halfway around the world with fantastic accuracy. We can create a livable environment for man in the cold reaches of space.

Thanks to the foresight of Secretary of Defense McNamara, we have conventional forces to give us some option in brush warfare situations besides resort to the massive deterrent of nuclear holocaust.

But it is becoming increasingly apparent that these conventional forces lack the non-nuclear advanced weaponry which might come out of a determined effort by this industry to provide it.

The fighting in Viet Nam and Santo Domingo is distressingly similar in tactics and equipment to the fighting in World War II and Korea.

In the 20 years since World War II, we have reached the Moon, but have found no better way of knocking out a bridge than pointing an aircraft at it, an aircraft highly vulnerable to ground fire in the hands of even unsophisticated opponents. Even *Bullpup* hasn't solved the problem.

This is ridiculous. Surely the fantastically brilliant minds of this industry can come up with some very effective unconventional ways of doing these conventional tasks.

But as yet the industry does not seem to have grasped the importance of such programs despite repeated pleas from DOD officials who emphasize the need for them.

What is needed is some really way-out thinking on these problems. But way-out thinking is no good without a grasp of the realities concerned. Industry firms, with support from the Pentagon, should undertake to indoctrinate their top thinkers by sending them out to the world trouble spots. Let them talk to the soldiers, sailors and airmen who are grappling with the problems of finding and destroying the enemy, his equipment, his strongholds and his supply lines. Let them learn for themselves about the environment of jungle and mud and monsoon which must be overcome. Let them discover the effectiveness of a single concealed sniper against advancing troops.

Then let them come home and devote some really creative thought to meeting the needs of limited warfare. Only by doing this can imagination be coupled with reality to produce weapons that can do an old job in a Space Age way without resort to nuclear devastation.

If this is not done, then the U.S. may lose the conventional warfare options which Secretary McNamara has labored to create. The resources of the U.S. in limited warfare are far from exhausted, even with two such simultaneous actions on opposite sides of the world. But already some observers are raising the question publicly of whether we can afford to place ourselves in this position. They are asking whether we should not consider use of tactical nuclear weapons to provide us with sufficient advantage against overwhelming manpower.

It has even been suggested that the only alternative to this at the moment may be a trip, hat in hand, by President Johnson to our allies to ask for assistance in manpower, much as Winston Churchill turned to the U.S. at the beginning of World War II for material aid.

WE DO NOT BELIEVE either course is yet necessary. We abhor any suggestion that nuclear weaponry be employed. Regardless of its effectiveness, the black stain of such a decision would seep down through history like the foulest of inks. Nor is the U.S. in such dire straits that its President must plead for help from unwilling allies.

But the time could come when these would be the only alternatives left to the U.S. There are dozens of other trouble spots in the world where U.S. commitments might involve us tomorrow or the next day. Eventually, our resources—and indeed, our patience—could be stretched thin.

The way out of this dilemma is to find a more effective way of doing the job which confronts us. The key lies in this industry.

The Pentagon has pointed out the needs and problems of tactical warfare. It has taken this into account in its budget planning. For no other reason than financial self-interest, it behooves companies with special talent in advanced technology to devote considerable time and talent to this area.

It is a military axiom that generals plan for the next war in terms of the last one. But it is not generals alone who bear the burden of this. It now is time to break the cycle with a determined joint military-industry effort to deliberately seek exotic solutions to unexotic tactical problems.

There have been some efforts along this line. But the front pages daily provide evidence that these have fallen short. The time has come for the Pentagon to more actively involve the best thinkers in industry in its troubles in Viet Nam and elsewhere, perhaps with a national conference devoted solely to the subject, followed by a widescale program of personal visits to the scenes of conflict.

Unless this is done, we may one day face some ugly alternatives.

William J. Coughlin

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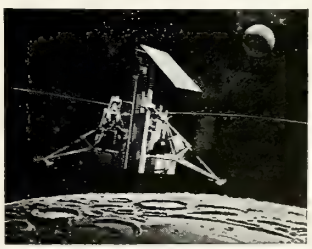

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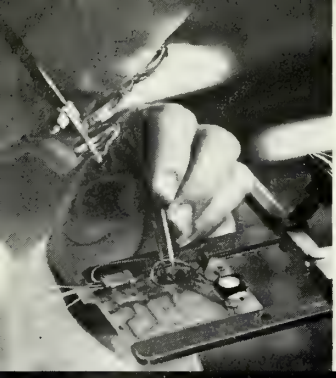

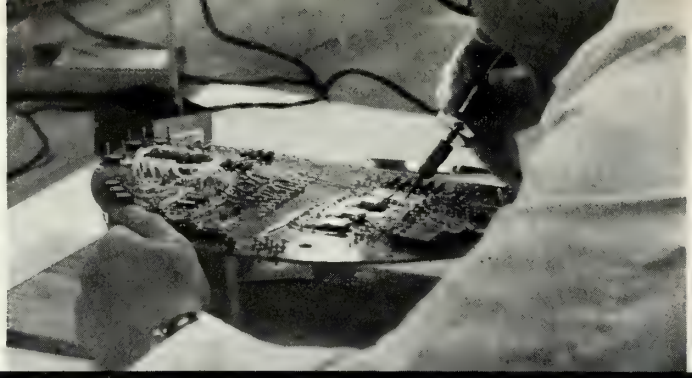

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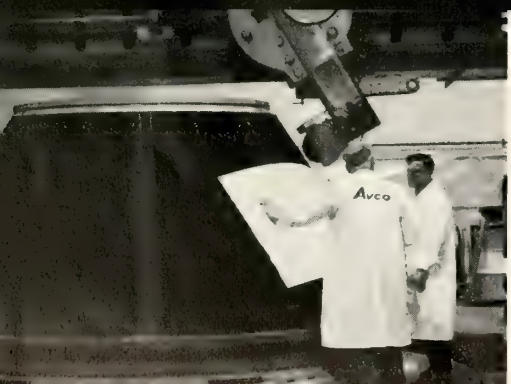

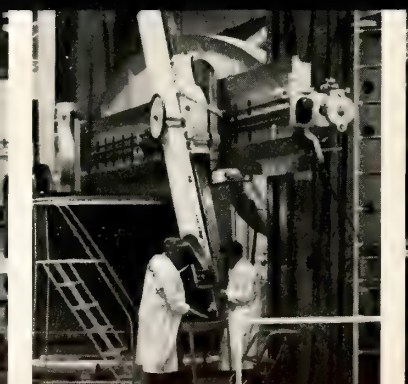

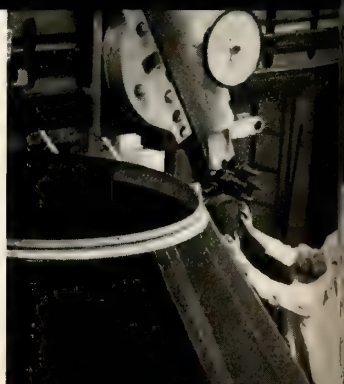

MAY 31, 1965

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THE COVER

Dr. Winston E. Kock, director (center), flanked by Dr. Albert J. Kelley, deputy director (left), and Franklyn W. Phillips, assistant director for administration, consider permanent plans for NASA's Electronics Research Center. M/R's ERC special report begins on p. 23.

CARLETON GREELEY

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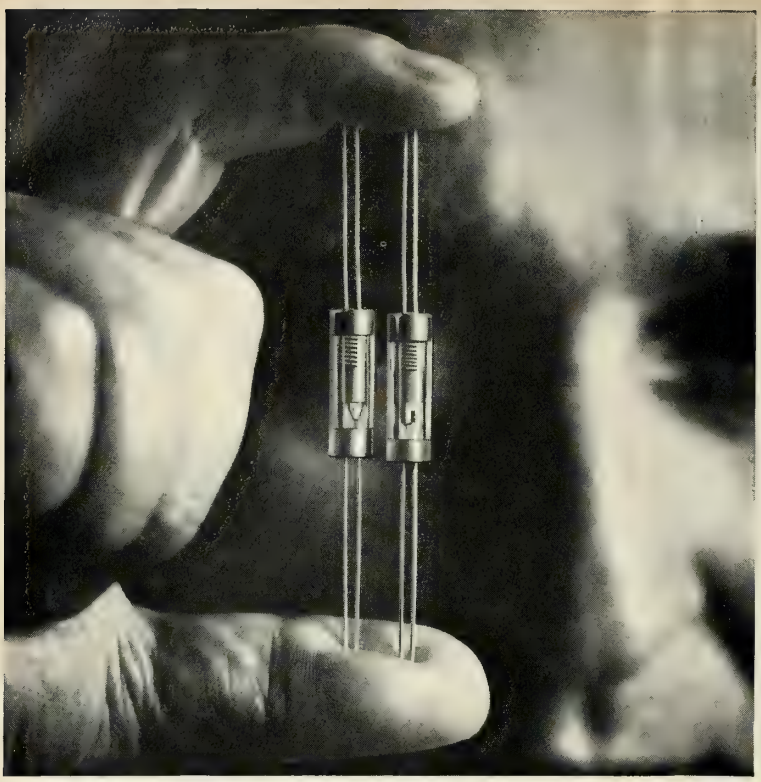

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letters

Patent Injustice

To the Editor:

Bravo for Senator Russell B. Long! His insistence that aerospace industry by reason of its Federal employment surrender patents which it has taken in turn from individual inventors by reason of *their* employment has laid bare the double standard.

While his is a cockeyed bill by strict interpretation, since it says nothing whatever about the disenfranchisement of the individual inventor who has *created* the intellectual property at the bottom of this squabble, it does expose the patent injustice (and national disgrace) of the patent assignment agreement system which so neatly subverts the U.S. patent law.

The U.S. patent law was written to encourage and protect the *inventor* and not the *company*. Ben Franklin Miessner has resoundingly proven that the great majority of inventions in the U.S. today as always are originated not by money, committees, administrators or government-supported research but by—guess who? Inventors.

John H. Bloomer
Manhattan Beach, Calif.

AF Quality Control

To the Editor:

Perhaps the Air Force is not really permitted to enforce an effective quality control system. Perhaps their top management knows that with present low profit margins, quality is seriously endangered. Perhaps all they are empowered to maintain is a sort of high-priced hardware sitting service.

This is the conclusion that I have arrived at when otherwise inexplicable facts confront me. As badly mimeographed milspecs, MSFS's and DOD directives are distributed, read, stamped, initialed, any effort by the conscientious engineer to enforce them is frustrated in a most vicious manner. If he is the insistent type, he is given unsatisfactory reports, denied promotions, training slots and intimidated with threats.

It will be worthwhile for the Air Force to analyze personnel reports, *especially of graduate engineers about to be fired*. I believe they will be surprised to find that the highly trained engineer with post-graduate credits and wide experience fails so miserably at quality control, while the non-technical long-time civil service employee simply shines at the job. Of course, some engineers have seen the light. They are promoted to higher positions. They have absorbed the principle that their work is to shuffle papers, put out glowing reports, attend meetings, go on t.d.y.'s

Naturally, you must always justify your position, and make sure that you are in the clear when some defective item shows up. But as long as you follow the p.d., a clumsily worded bunch of generalities, you are o.k. So what if the TIG welding is lousy, the X-rays of poor quality, contamination ever-present, parts costly and overdesigned, $2,000,000 tanks crack, and

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heat-treatment faulty. That's the contractor's problem and as long as he adheres to specifications, that's all you have to worry about. You can always put a Zero-Defects sticker on your car, and drive home.

With this attitude, secretaries will soon greet you politely, third-rate office clerks will no longer forbid you to use certain telephones, and they may even send you places at Government expense to look into a contractual matter that could be settled by mail.

To rephrase my original premise, if the Air Force is convinced that enforcing good quality control is impossible because of factors over which it has no control—well, then why maintain costly departments, allow training slots, make motion pictures, publish pamphlets? They could also save themselves the trouble of firing some poor devil of an engineer who thought, mistakenly, that his country deserved the best.

Alfred Dreyfus
Los Angeles

Pulse Compression

To the Editor:

Re the article "Radar, ECM Gains Seen with Sperry Delay Line" (M/R, April 26, p. 34):

It may be that the author has overlooked the tremendous advances in the state of the art of pulse compression systems in the last year or so. In particular I refer to the use of metallic strip dispersive delay lines as the dispersive elements of pulse expansion and compression.

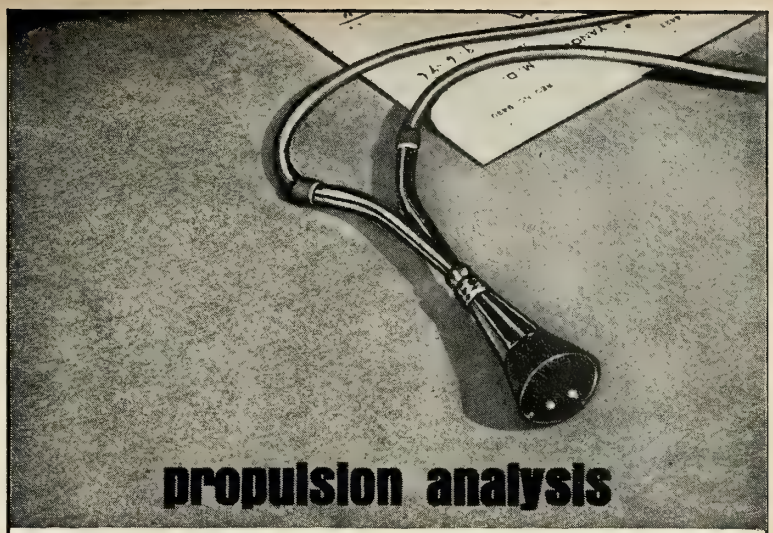
In the case of the metallic strip dispersive delay lines, PC systems with bandwidths up to 4.5 MC and differential delay dispersions of the order of many hundreds of microseconds have been built by Andersen Labs. Many of these systems are in service in a wide variety of applications. The insertion loss of these delay lines is typically less than 40 db, and no cryogenic cooling is required. A typical unity gain channel providing a 3.0 MC bandwidth at 30 MC and 40 μsec of delay dispersion, occupies approximately one-half cubic foot of space, weighs approximately five pounds and costs less than $3,000 without the weighting filter. Time sidelobes of —30 db or better have been achieved.

In the case of the diffraction grating delay line, used in Andersen Labs' DELECON pulse expansion and compression systems, a bandwidth of 20 MC at 45 MC has been achieved in a system providing a 400:1 pulse compression ratio and 40 MC bandwidths at 90-100 MC are expected within a year.

These DELECON systems provide a remarkable degree of delay linearity and time sidelobes as low as —35 db have already been achieved; —40 db sidelobes are believed attainable with use of better weighting filters. No delay equalization is required.

Insertion loss of the diffraction grating delay line is higher than the metallic strip delay line, being of the order of —65 to —70 db. This disadvantage is overcome by use of higher-power drive amplifiers.

S. E. Rittenburg
Andersen Laboratories, Inc.
West Hartford, Conn.



propulsion analysis

The heart of a space vehicle is its propulsion system. The human heart's ability to function beforehand can be determined by stethoscopes, cardiagraphs and other equipment. From a test standpoint, the rocket's heart is more complicated. Predetermining a rockets behavior by testing alone would be impossible and hence elaborate analog and digital representations of the propulsion system are required to establish the system characteristics and point out the areas for test evaluation.

Once on the moon or in space a rocket system must be extremely reliable and predictable in its behavior. To meet these demanding requirements every aspect of the pressurization, feed and engine systems, in all conceivable modes of operation must be evaluated and understood.

Therein lies the challenge, not only in propulsion analysis but in other critical areas as well. Qualified individuals who would rise to it will find that Grumman provides the facilities, the stable work atmosphere and the growth potential that enables them to meet it head on. The following specific opportunities invite your inspection and action.

Rocket Propulsion Engineers—Engineering degree plus several years experience with liquid rockets. Involves challenging duties in the area of steady-state, transient, and malfunction performance analysis as applied in manned space vehicles. Both junior and senior positions available.

Reaction Control System Engineers—Technical specialist to perform analysis of small pulsed rocket engines and pressure fed propellant systems. A firm background in liquid rocket engines desirable.

Gas Dynamics Engineers—BS in AE or ME with applicable experience, to be responsible for one or more of the following: Internal Aerodynamics, Ducted Fans, VTOL, Thrust Deflection Systems, Compressible Fluid Flow, Shock Wave and Boundary Layer Theory, Inlet, Nozzle and Exhaust System Flow Analysis; Method of Characteristics; Wind-tunnel & Duct Lab testing.

Propulsion Support Equipment Engineers—BS in ME or AE with a minimum of 2 years engineering experience in the design of support equipment for aircraft or spacecraft propulsion systems.

Propulsion Systems Test Operations Engineers—BS or equivalent with experience in test operations of hypergolic liquid fuel rockets. Work will include preparation of installation, validation and operation procedures followed by implementation of these procedures in the White Sands Propulsion Systems Development Facility. Experience in atmospheric and aptitude chamber test facility operations with particular familiarization in fluid, pneumatic & structural systems is desired.

Fluid Power Design Engineers—BS in ME, CE or AE with a sound background in the design, development & installation of fluid power components and systems in military aircraft. Must be thoroughly familiar with all controlling military design requirements & specifications.

Stability & Control Engineers—BS or MS in AE, EE or ME, to perform dynamic analyses in support of vehicle aerodynamic design effort including automatic flight control systems, covering flight regimes from hovering to hypersonic. Responsibilities include: analysis of uncontrolled vehicles; establishment of stability augmentation system parameters; evaluation of vehicle flying qualities; sizing of force & motion augmenters; evaluation of transient performance and stability of flight control modes; analysis of vehicle dynamic response in disturbed flight and special flight situations. Positions available at all experienced levels.

To arrange an immediate interview, SEND RESUME to Mr. P. M. Van Putten, Manager Engineering Employment, Dept. GR-86.

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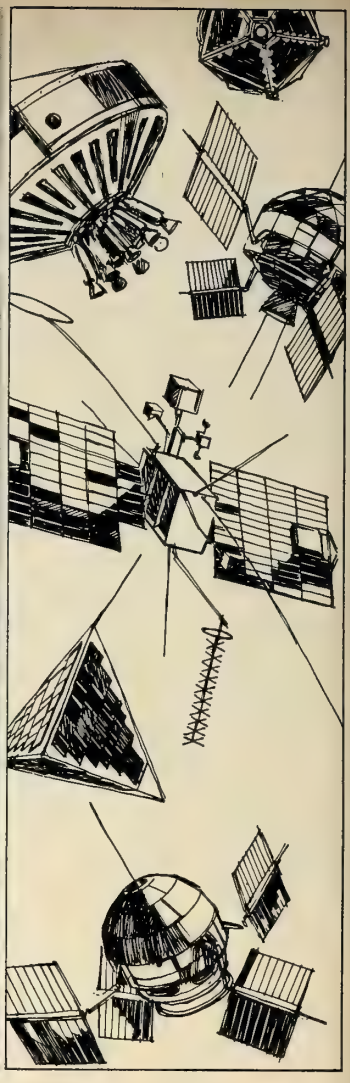

SUBS AND SPACECRAFT

TRW now applies the discipline of space, demanding reliability and longevity, to Anti-Submarine Warfare (ASW). TRW Space Technology Laboratories has been awarded a systems integration and test support contract for the Navy's overall ASW program. The vital responsibilities assigned to TRW create opportunities in: Operations Analysis, Engineering Analysis, Systems Analysis, Program Analysis, Test Project Engineering, Test Evaluation Engineering, Test Planning Engineering and Configuration Control Engineering.

TRW's participation in 90% of all U.S. space launches has created openings in: Theoretical Physics, Systems Engineering, Radar Systems, Experimental Physics, Applied Mathematics, Space Communications, Space Physics, Antennas and Microwaves, Inertial Guidance, Analog Computers, Solid State Physics, Computer Design, Telecommunications, Digital Computers, Guidance and Navigation, Electro-mechanical Devices, Engineering Mechanics, Weapons Systems, Applied Aerodynamics and Propulsion Systems. For information about TRW opportunities in Los Angeles, San Bernardino, California, Houston, Texas, Cape Kennedy, Florida, and Washington, D.C., write TRW Professional Placement, One Space Park, Redondo Beach, California, Dept. M-5. TRW is an equal opportunity employer.

TRW SPACE TECHNOLOGY LABORATORIES

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6498

The Countdown

WASHINGTON

Goodwill for ERC in Boston

Prominent electronics industry executives in the Boston area who have lost top officials to the Electronics Research Center are still very much in ERC's corner—in fact, say they appreciate not being raided by NASA. Reason: recruitment has usually stopped at one or perhaps two men from any single firm.

Outside Employment To Rise with GT-5

NASA's extravehicular experiments, which will begin with *Gemini 4*, are due to increase sharply during the *Gemini 5* flight. An astronaut then is expected to move the spacecraft adapter—while floating in space—take out tools and perhaps perform some simulated repair work.

Gemini/Titan III-C/MOL Target Unchanged

Target date of late 1967 or early '68 for the first unmanned launch of the modified *Gemini/Titan III-C/MOL* configuration is still firm, despite DOD delays in arriving at an *MOL* decision, Air Force sources say. Land recovery in the Wendover (Utah)-Edwards (Calif.)-White Sands (N.M.) triangle is still a requirement in the program, which also calls for a shirt-sleeve environment inside the laboratory canister for manned versions of the system.

Seven-Segment Strap-ons Eyed for Titan III-C

Use of seven-segment 120-in. strap-on solid motors, instead of the original five-segment strap-ons, is the method now being considered by the Air Force Systems Command for uprating its *Titan III-C* booster. Other alternatives, including use of two or four *Minuteman* boosters or 156-in. solid strap-ons, have fallen from favor.

Now About That Appropriation . . .

Testimony by top NASA officials before the Senate Independent Offices subcommittee—the last committee the space agency must face in getting its Fiscal Year 1966 funding approved—has been put off until June 16. Postponement, from an earlier date in May, follows the pattern set this year of arranging Congressional appearances to follow impressive space performances.

Tentative Curb on Aerospace Corp. Growth

Aerospace Corp. may henceforth have to get specific approval from Congress before it can expand its physical plant. The House Armed Services Committee has included in a military construction bill it approved last week a clause prohibiting the Government-owned non-profit firm from either building or acquiring land without authorization to the Air Force by Congress.

Optical Satellite RFP's Going to 100+ Firms

RFP's for the *Optical Technology Satellite* study will be sent by Marshall Space Flight Center to more than 100 companies. Two contracts will be awarded—parallel, identical preliminary design studies for an *OTS* system including the satellite, launch complex and ground support system. Contractors will do theoretical and analytical research, laboratory experiments and testing for development of conceptual designs for all elements of the system. In addition, they'll develop central designs for experiments to go aboard *OTS*.

Langley Contending for Meteoroid Assignment

NASA Office of Advanced Research & Technology favors selection of Langley Research Center to direct the proposed cislunar and deep-space meteoroid detection satellite program. One group that could take over the program is the Project *Fire* management team, whose program is winding up. Other contender is the Marshall Space Flight Center, which is directing the *Pegasus* meteoroid detection satellite series.

New NASA Deputy Moving In

William B. Rieke has been appointed NASA deputy associate administrator for industry affairs, effective June 2. He has been deputy associate administrator for management in the Office of Manned Space Flight. Rieke is replacing George Friedl, who is returning to his home in California.

INDUSTRY

EOS Meter To Study GT-4 Static Buildup

An electrostatic potential meter developed by Electro-Optical Systems is scheduled to be flown for the first time on *Gemini 4*. The instrument, which will also go aboard *GT-5*, is designed to establish whether or not electrostatic buildup could result in a major discharge during rendezvous. Some experts believe the phenomenon may have caused electronic failures and premature ignition of boosters in the past.

Algol Stopped in One-eighth Second

A "major breakthrough" in propulsion safety has been claimed by Aerojet-General as a result of stopping an Algol solid motor running at full thrust in ⅛ sec.—by injecting water into the combustion chamber. The static test showed for the first time that large solids can be quenched immediately with a small amount of water—in this case, less than 40 gallons. Aerojet says the same test represented progress on a malfunction detection system for large solid rockets.

Autonetics Building Three-Ounce Converter

North American Aviation's Autonetics Division is applying microelectronics to the development of a high-speed analog-to-digital converter for spacecraft. The rugged device, being built under contract to Jet Propulsion Laboratory, will weigh less than three ounces and meet environmental specs suitable for *Mariner* probes.

INTERNATIONAL

Aussies Leaning Toward Redeye

General Dynamics/Pomona's *Redeye* ground-to-air guided missile is considered a strong favorite for selection by the Australian Army. Hoping to have such a weapon in service during their current three-year defense program, the Australians reportedly are gathering all available data on the U.S. missile.

Paris Air Show Touted as Biggest in World

Sponsors of the upcoming Paris Air Show report that the event will be the biggest ever staged anywhere. The unprecedented number of exhibitors—450—includes 82 space-oriented firms, compared with 36 just two years ago. Fifteen nations will be represented and 450 aircraft will be on hand.

these 3 points tell you all about us:

1

Dynamics Research Corporation was founded 10 years ago by a former M.I.T. Instrumentation Lab group whose work had been noteworthy in the inertial guidance and navigation field. Their successes on a list of DOD and NASA projects (Polaris, Apollo, Titan, Minuteman, Saturn) have sparked a vibrant growth.

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a) Systems engineering (design, integration, instrumentation) — an integral unit that defines, studies, and solves advanced problems in navigation and guidance.

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$6.44 Billion for RDT&E

The Senate Armed Services Committee has agreed to cuts made by its House counterpart in DOD FY 1966 requests for research, development, test and evaluation.

In ironing out differences in the two bills already passed by the House and Senate, the conferees settled on an RDT&E figure of $6,444,500,000, which added to procurement brings the total DOD Procurement and RDT&E Authorization Bill to $15,402,800,000.

Ironically, the conference bill is $99,400,000 more than the bill as it passed the House, $119,000,000 more than when it passed the Senate, and $105,600,000 more than the President requested. The plus factor comes from the addition of $150.5 million for a nuclear-powered guided missile frigate.

Restrictions imposed by language inserted by the House to the effect that any reductions in RDT&E are not to be taken from the $150-million fund for the *Manned Orbiting Laboratory* were accepted by the Senate. However, a cut of $29 million in military astronautics was imposed.

Bullpup Earns Respect

Navy's *Bullpup* missile, not notable for its successes in the early days of the operations against targets in North Viet Nam, is now performing "very satisfactorily," area commanders report.

Vice Adm. Paul D. Stroop, Commander, Naval Air Force, U.S. Pacific Fleet, noted that lack of familiarity with what the weapon would do under actual combat conditions was responsible for its undistinguished record in the hands of Navy pilots in the earliest raids. Stroop said that on at least one occasion a single *Bullpup* has knocked out an entire bridge.

Mariner To Use New Antenna

The new 210-ft. dish is one of four antennas at the Goldstone Deep Space Instrumentation Facility (DSIF) scheduled for use during the *Mariner IV* Mars encounter. First picture from the spacecraft tape recorder will be received at the Johannesburg DSIF. This is likely to be released to the public 38 hours later.

Probability of mission failure due to radiation belts around Mars causing the Canopus sensor to lose its lock, is now considered low. The alternative all-inertial stabilization is not scheduled for use.

The plasma probe has started to return data again after transmission loss in March. Abnormally low readings, thought to be caused by an instrument failure, may have actually represented an unusual solar plasma condition.

This information was disclosed by a Jet Propulsion Laboratory official at the AES/AAS Space Electronics Symposium at Los Angeles May 25-27.

NERVA Reactor Re-started

The NRX-A3 NERVA nuclear rocket reactor ran at full power—1,100 megawatts—for approximately 13 minutes and then at significant power levels for nearly 18 minutes in a re-start test at Jackass Flats, Nev., on May 20.

The test time at power was limited by the available hydrogen fuel supply and represented the longest power run of the Westinghouse-designed reactor. Preliminary data indicates operation was within design predictions.

This was the second test of the reactor. In an earlier run on April 23, a control signal cut the power run short. The signal initiation was apparently spurious since no equipment malfunction was found in subsequent equipment examinations.

High-tolerance graphite components such as the reflector cylinder, support blocks, filler blocks and strips fabricated by Hi-Temp Materials Corp., functioned as predicted.

Westinghouse's Astronuclear Lab has the development responsibility for the reactor under Aerojet-General Corp., prime contractor for the NERVA engine program.

Sarnoff Seeks Safeguards

An updating of the nation's communications policies and regulations is necessary to safeguard U.S. leadership in global and satellite communications, David Sarnoff, chairman of Radio Corp. of America, has indicated.

Addressing the Armed Forces Communications and Electronics Assn. in Washington last week, Sarnoff called for a unified national communications policy recognizing the fact that competition in international communications is now between nations—not within them.

In the face of increased foreign competition, said Sarnoff, "America cannot, in my judgment, successfully operate a system of global communications with one company responsible for international voice transmission, five others for international record transmission and with unresolved jurisdictional lines between the single American satellite entity (Comsat Corp.) and all the international communications carriers."

As a possible solution, Sarnoff again proposed creation of a single, independent U.S. company—under appropriate Government regulation—which would unite the facilities and operations of present U.S. common carriers, both voice and record.

NASA Operates New Magnet

NASA scientists have successfully operated a high-field-strength cryomagnet with a field volume 4.5 in. in diameter.

Developed at Lewis Research Center, the low-temperature magnet will provide research facilities for magnetics, solid-state physics and plasma physics. The effects of high-strength magnetic fields on life can also be examined in the cryomagnet.

Running the device with eight coils and a power input of 1 million watts, Lewis researchers have obtained a continuous magnetic field of 200 kilogauss.

Shots of the Week

NASA scored two major successes last week with the launchings of the Project *Fire* re-entry experiment May 22 (see p. 21) and *Saturn SA-8* and its *Pegasus* meteroid detection satellite May 25 (p. 17).

- French space authorities on May 17 announced the second successful test flight of the *Emeraude* space booster. It was topped by a mockup of the *Topaze* rocket, which is to be the second stage of the *Diamant* launcher that France is developing.
- The Soviet Union launched the 67th scientific satellite in its *Cosmos* series on May 25.
- NASA test pilot Milton Thompson flew the *X-15* rocket plane to an altitude of 180,000 ft. and a speed of 3,341 mph May 25. Primary purpose of the flight was to check out the pilot and plane for other high-altitude, high-speed flights later in the year.

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*Through **all** phases of rocket flight!*

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- powered boost
- stage separation
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with the Raymond
Model 1849
MINIATURE RECORDER

look

at the environments through which this recorder has been tested!

Shock – 50g, 11ms; 500g, 1½ ms.
Vibration – 20g rms Random to 2,000 cps. 10g rms Sine-slow sweep to 2,000 cps and back.
Sustained Acceleration – 200g – along axis. 150g – across axis.
Temperature Range 32°F to 160°F.
Altitude – Unlimited.

During the above tests, tape speed was 30 ips; wow and flutter was less than 5% peak to peak; and power consumption was below 10 watts.*

look

at the salient features of Model 1849!

Size – 4" diameter x 4" long.
Weight – 2.8 lbs.
Tape Capacity – 113 feet of 1 inch 1 mil, Mylar tape.
Recording Time – 45 seconds @ 30 ips.
Tape Speeds – 30, 15, 7½ or 3¾ ips.
Tape Speed Accuracy – ± 0.5%.
Head – 14 track in line, record/reproduce.
Motor – hysteresis synchronous.

look

at the added advantages gained from the 1849 reproduce capabilities!

- **remains sealed** — avoids handling of tape and transport to prevent contamination.
- **provides readback on launch pad** — for final payload checkout.
- **provides readback in laboratory** — saving time in all phases of testing.
- **provides data playback in flight.**

** These tests have been duplicated by the Instrument Research Division of NASA's Langley Research Center at Hampton, Va.*

Write for catalog sheet, or request demonstration by a Raymond representative.

Raymond
CAPABILITY · RELIABILITY

RAYMOND ENGINEERING LABORATORY, Inc., 1011 Smith Street, Middletown, Conn.

• The Air Force successfully launched a *Minuteman II* ICBM from Cape Kennedy on May 25.

Minuteman To Stay Until '70's

The $1-billion modernization program for *Minuteman* planned by the Air Force will continue for the rest of the present decade and possibly into the early 1970's, with the Boeing Company's share of the operation expected to total more than $400 million as systems integrator.

The firm estimates that employment in its *Minuteman* effort during the modernization will remain at a level of about 6,000.

Air Force spokesmen have confirmed the consideration of the use of *Minuteman* in a follow-on anti-satellite system. In any event the *Atlas* booster has apparently been dropped from serious consideration.

A/SWA Elects Officers

The Aviation/Space Writers Association during its annual meeting last week in Albuquerque, N.M., re-elected all its officers but one. Incumbent executive secretary Ralph H. McClarren did not seek re-election.

Re-elected to their former posts were: president, Thomas M. Self; first vice president, Richard C. Kiefer; second vice president, James Cahill; and third vice president, Jerry B. Hannifin. Incumbent Treasurer Leslie V. Spenser was elected to the newly created office of Secretary Treasurer.

MISSILES AND ROCKETS senior engineering editor William S. Beller and contributing editor David A. Anderton were among the recipients of A/SWA awards during the meeting.

New Re-entry Radar Sought

The Air Force expects to issue RFP's early in June for project definition of a new radar for use with DOD re-entry system evaluation programs on its Western Test Range.

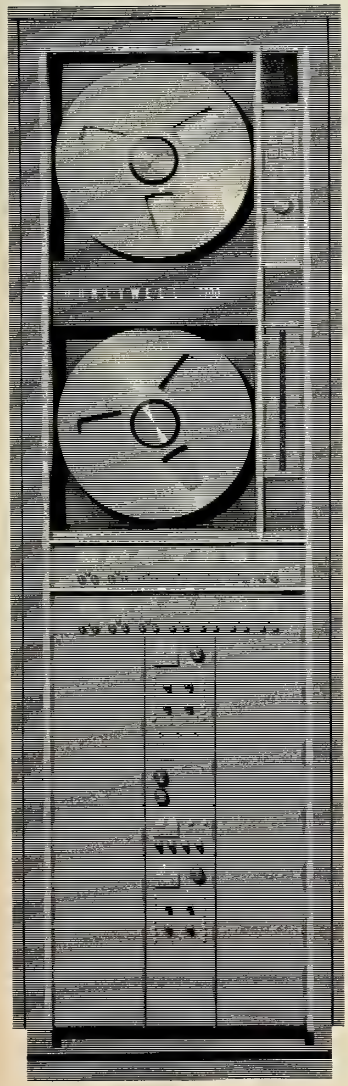
The new re-entry system evaluation radar (RESER) must be transportable to a limited degree because of its anticipated use at remote sites, away from continental United States. Stipulations that off-the-shelf hardware should be used in its fabrication wherever possible indicate that the equipment, sought for use in connection with the *ABRES* effort, is the mechanically directed dish type.

If the early PDP phase performance is successful, a full development contractor will be chosen. The acquisition contractor will be responsible for design, fabrication, installation and test of the radar, plus initial operation and maintenance.

Circle No. 24 on Subscriber Service Card

The Honeywell 7700 introduces these four significant advances in analog magnetic tape instrumentation:

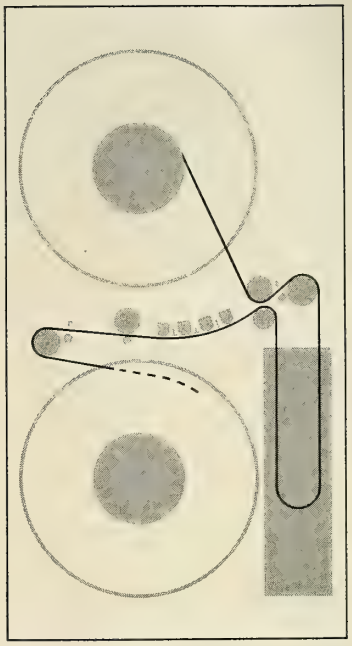
TIME DISPLACEMENT ERROR—Timing errors between record and playback can originate in dimensional changes in the tape caused by temperature, humidity and tension variations as well as differences in tape speed between record and playback. These effects have been minimized through use of a tape-controlled servo on the playback mode. Until now, however, high inertia systems could only reduce instantaneous timing errors to about 1 millisecond. The new Honeywell 7700 low inertia, high-response servo reduces this error to 1 *microsecond* at 120 inches per second.



FLUTTER—In the past, flutter has been reduced by use of high inertia drive systems which lose their effectiveness at low frequencies and low speeds. The high-response servo in the Honeywell 7700 virtually eliminates flutter below 100 cps and holds wideband flutter below 0.25% from DC to 10KC at 60 ips.

DYNAMIC SKEW—If data on two or more channels are to be compared, it is essential that varying time differences between channels caused by dynamic skewing of the tape be reduced. The use of vacuum column isolation and a 13-inch edge guide ahead of the record-playback heads reduces dynamic skew in the Honeywell 7700 to approximately one-third of that in state-of-the art analog systems.

SIGNAL/NOISE RATIO—Noise caused by electronics, tape and the tape transport can mask small amplitude data changes. Efforts to improve linearity, drift and other parameters are fruitless if a high percentage of noise is present. The



Honeywell 7700 will produce signal-to-noise ratios as great as 48 to 52 db rms. This is a 2-to-1 improvement over the 40 to 44 db noise found in other FM systems.

The Honeywell 7700 is an 80 KC FM-640 KC Direct system built specifically to preserve the quality of your most critical data.

For complete specifications, call a scientific field representative at your nearest Honeywell office, or write Mail Station 402, Honeywell, Denver Div., Denver, Colo. 80217. In Canada: Toronto 17, Ontario.

DATA ACQUISITION SYSTEMS

Honeywell

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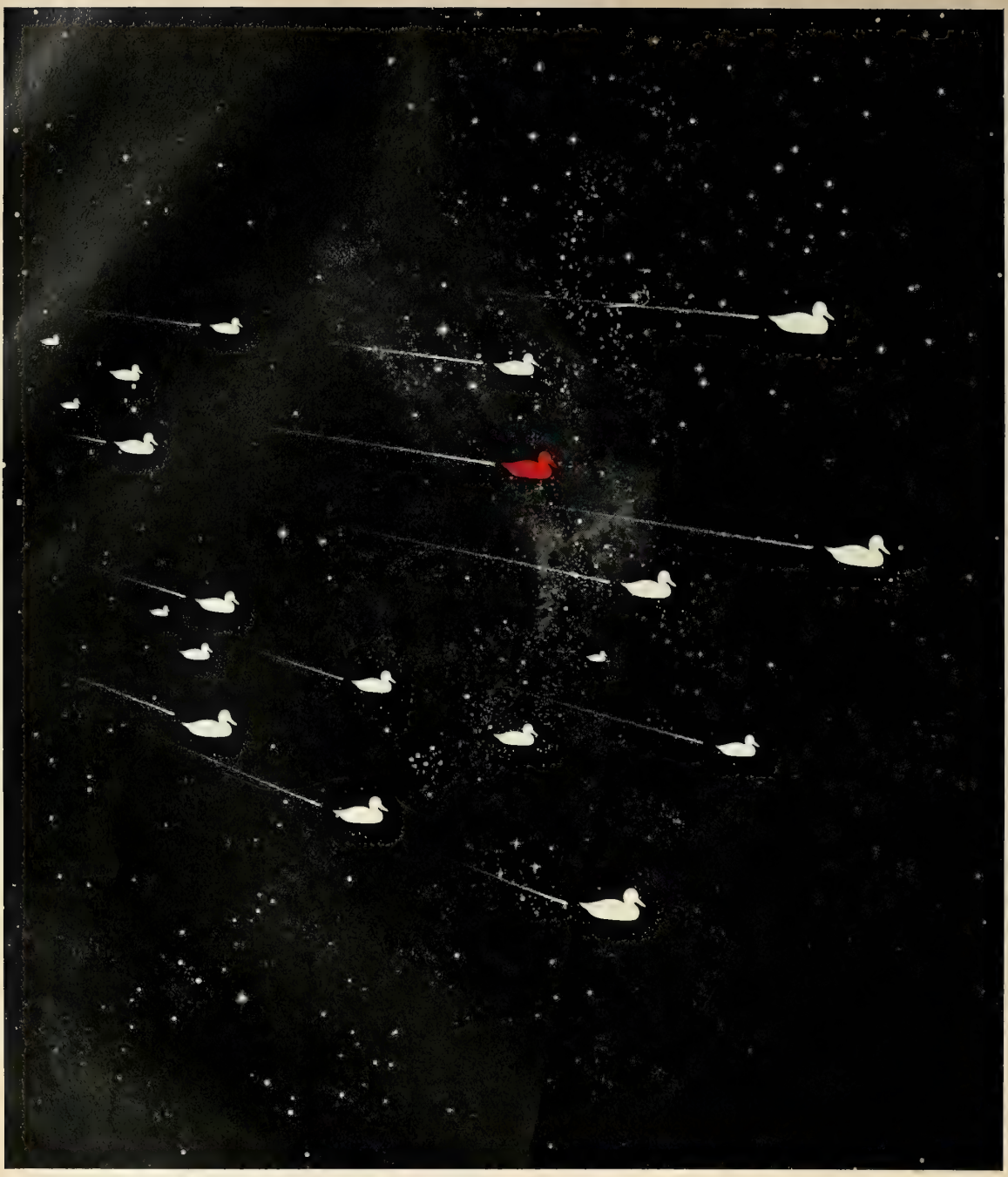

How not to be decoyed. Deciding which one isn't a phony is a typical job for *infrared* techniques, of the kind that are being perfected today by Sperry. Precision target discrimination . . . multiple target tracking . . . wide field detection and warning . . . infrared imaging . . . modulated infrared beaconry . . . these are some of the areas we are working in, and just some of our capabilities. Still more sophisticated ground and aerospace infrared techniques are at various stages of Sperry development. ☐ The Electro Optics Group is a reservoir of other specific skills, too — ring laser gyroscopics, laser ranging trackers, laser metrology, electro-optical information processing, optical correlation, gas and crystal laser applications. **ELECTRO OPTICS GROUP, Sperry Gyroscope Company, Great Neck, New York.**

SPERRY

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Circle No. 26 on Subscriber Service Card

White Plans To Leave GT-4 Capsule

Conditions permitting, astronaut will spend 12 minutes outside spacecraft during second orbit; NASA describes extravehicular gear

by Jinx Mercer

ASTRONAUT Edward H. White plans to emerge from the spacecraft during the second orbit of the upcoming *Gemini-Titan 4* mission and float in space at the end of a 25-ft. line.

This surprisingly bold step in extravehicular activity (EVA) was announced May 25 in a special press conference at NASA's Manned Spacecraft Center.

Dr. Robert H. Gilruth, MSC director, said the decision to include EVA on *GT-4* was made only last week.

Christopher C. Kraft, assistant director for flight operations at MSC, said the preparation for EVA will begin at second apogee over the Indian Ocean on the night side. The crew will remove a chest from a starboard stowage slot, and from an aft food container. The cabin will be partially decompressed (2-3 psi) for suit integrity checks, then decompressed completely when the spacecraft moves into the daylight.

The status of the EVA systems will be reported over Hawaii, Kraft said. Nearing the U.S., White will open the hatch and stand up. A "go or no-go" decision for complete emergence will be relayed to the crew from the Mission Control Center in Houston.

Kraft said the pilot will spend a total of 12 minutes in space making observations and taking pictures with a 35-mm camera. A motion picture camera, mounted inside the cabin, will record his activities. James A. McDivitt, spacecraft commander, will operate spacecraft-attitude thrusters to hold the camera on White.

White will begin ingress over Cape Kennedy and will close the hatch before the spacecraft loses voice contact with the Ascension Island range station. The spacecraft will be re-pressurized before it enters the night side of the orbit, Kraft said.

Richard C. Johnston, chief of the Crew Systems Div. at MSC, described the EVA equipment:

● **Umbilical**—The nine-pound, gold-coated umbilical houses oxygen, biosensing and voice communication lines and is plugged into the suit inlet port and electrical connector. A shorter line, called a mechanical tether (safety line), short-stops tension loads on the more critical life-supporting and electrical lines. It is designed for tensile stress of 1,000 lbs.

● **Ventilation control module**—The eight-pound chest pack developed in-house contains a 10-minute emergency supply of oxygen and a demand regulator valve to maintain 3.9 psi of oxygen in the suit by relieving excess suit pressure and exhaled gases directly into space. The pack measures 13 x 6 x 2 in. and plugs into the suit outlet port. It is held against White's chest with Velcro tape. A line from the emergency oxygen supply is plugged into the drink port of the helmet. Emergency oxygen flow is actuated manually, Johnston said.

Gemini Manager Charles W. Mathews said that the EVA equipment, including the EVA spacesuit (M/R, April 19, p. 24), has undergone extensive testing and evaluation. For example, White has spent more than 60 hours in his suit and has performed 110 egress-ingress runs during KC-135 zero-gravity flights. Although McDivitt will be wearing an EVA suit, his will not include the micrometeoroid and thermal protection layers.

In the meantime, the inclusion of EVA in the second orbit of the mission complicates an orbit-adjustment maneuver planned at the second apogee to establish a five-day orbit lifetime by correcting for booster underspeed.

EVA displaces a Department of Defense experiment (D-9), which consists of making star-horizon angular measurements through various filters for autonomous navigation. The experiment was moved to this early flight at the request of the *Apollo* program office, which is studying man-sextant performance to better evaluate the manual features of an optical tracking system for the Lunar Excursion Module.

Astronauts McDivitt and White were to have made star-to-booster measurements very early in the mission, while the booster was still in orbit and near the spacecraft. Using the sextant, White was to have aligned the moving object (booster) with an inertially fixed object (star) on both day and night sides of the orbit. For night measurements, the booster is equipped with two high-intensity xenon flashing lights. ■

AT CAPE KENNEDY, Astronaut Edward H. White II, pilot for Gemini-Titan 4 mission, prepares to enter the spacecraft during wet-mock simulated test. White plans to leave capsule during second orbit, assuming conditions are favorable.

DOD Steps Up Weather Satellite Work

While relying on NASA and Weather Bureau for data, Pentagon has inter-service office working full-time on military requirements

by Donald L. Zylstra

RECOGNITION of the prime importance of accurate weather data in all defense operations has been underscored with new activity in the Pentagon on the part of a Joint Meteorological Satellite Program Office (JMSPO).

Three officers, one each from the Army, Navy and Air Force, have been assigned to JMSPO, which is directed by Air Force Col. Peter E. Romo, formerly staff meteorologist for Cape Kennedy and the Eastern Test Range.

In contrast with Dept. of Defense procedures in defense communications, where the trend has been toward development of communications satellite systems specifically tailored for their military functions, the defense establishment continues to depend on the United States Weather Bureau, a civilian agency, for most of its weather data. Satellite-derived information is obtained exclusively from the Weather Bureau's NASA-developed satellites.

Because of the overriding importance of quality satellite weather data to military operations and programs, JMSPO was established Nov. 23, 1964, as a permanent office to work closely with the Weather Bureau and with NASA to assure optimum liaison between these agencies and the armed services and to provide for early use of technological advances developed by military services in increasing the quality and capability of weather satellites.

JMSPO has the assigned mission of cooperating with the Weather Bureau in a continuous review of NASA's meteorological satellite development program and defining military applications of the nation's weather reporting system.

Before the establishment of JMSPO, coordination of military weather requirements and systems development was performed on a part-time basis by a succession of ad hoc groups. Establishment of JMSPO is an acknowledgement that weather-data-gathering activities and technology have advanced to a point where their sophistication and complexity now demand full-time effort.

Members of Col. Romo's three-officer staff include: Lt. Col. N. L. Durocher, Army; Cmdr. W. S. Houston, Navy; and Lt. Col. D. J. Eddleman, Air Force. Each is a meteorological specialist.

Romo reports directly on the DOD level to the director of DDR&E. Requirements are channeled to JMSPO from the Joint Chiefs of Staff and from each of the armed services through their representatives in the office. JMSPO staff members have just completed a tour of the Pacific to study that area's military weather needs; in the offing are similar visits to such military theaters as Europe, the Middle East and the Caribbean.

Real-time, continuous readout of weather data for the Department and its three armed services is the ultimate goal of JMSPO, such information to be provided by a national operational meteorological satellite system (*NOMSS*).

Currently, data provided by meteorological satellites is limited to types of information gained through optical sensors. Ultimately, weather satellites will be designed to provide the types of vertical data now provided by radiosonde equipment—giving temperature, pressure, humidity and wind readings in the atmosphere on Earth below the satellite's orbital position.

While this latter capability is many years away, probably in the 1970-1975 period, technologists in NASA and the Weather Bureau are hopeful of having a synchronous meteorological satellite (SMS) system operational by 1970 to provide 24-hour weather reports over the entire globe. Three satellites in such a system could provide reports over the entire Earth, with the exception of the polar regions.

● **Early launches**—First officially operational weather satellite being developed for the Weather Bureau will be the *OT-2*, scheduled for launch in the first quarter of 1966 into a 750-n. mi. circular polar orbit, with a period of about 113 min. *OT-2* will be equipped with two automatic picture transmission (APT) cameras.

A companion satellite, *TOS-A*, will be launched into a similar orbit carrying two advanced vidicon camera systems (AVCS) like those on the *Nimbus* satellite. Data acquired by the AVCS cameras will be stored for transmission to two Earth receiving stations —at Fairbanks, Alaska, and Wallops Island, Va.—when the satellite is in their vicinity. Ultimately, cameras capable of both the APT and delayed transmission functions will be incorporated in a single satellite.

Tiros satellites now operational include: *Tiros 9*, launched Jan. 22, 1965; *Tiros 8*, launched Dec. 21, 1963; and *Tiros 7*, launched June 19, 1963. *Tiros 9* has the cartwheel configuration, increasing its coverage to four to five times that achieved by the earlier spin-stabilized versions. *OT-2* and *TOS* satellites *A* through *E* will also have the cartwheel configuration.

JMSPO's function is to furnish military weather requirements through the Weather Bureau to NASA, the agency responsible for all weather satellite research and development. Data returned by operational satellites are acquired by the Weather Bureau and transmitted to DOD.

Navy acquires this data directly and distributes it over its own facilities to the fleet. The Air Force Air Weather Service receives Weather Bureau data and is responsible for its distribution to both the Air Force and the Army.

Since collection of weather data is an international effort of which the U.S. Weather Bureau is a major part, APT transmissions from satellites transiting specific locations on the planet are made available by the U.S. Government to any government or commercial agency that buys or constructs ground receiving equipment associated with the APT system.

● **Inputs**—The U.S. military services now have more than 100 of these standard receivers, developed by Fairchild Stratos Corp. for NASA, on order. Costing about $30,000 each, the receivers are also available to commercial firms such as airlines and television companies, as well as for universities and weather agencies in foreign countries.

Many inputs resulting in technological improvements in NASA satellites are furnished directly to NASA from DOD. Typical of such technology assists have been refinements of APT ground receivers; new satellite stabilization methods, sensors derived from non-meteorological armed services space-vehicle development; and data-handling and communications advances derived from military research and development. ■

Meteoroid Program May Be Expanded

Proposal to extend cislunar detection project into deep space may be acted upon in six weeks; SA-8 Pegasus II launch praised

OFFICIALS IN THE OFFICE of Advanced Research and Technology would like to expand the cislunar detection satellite program to cover deep-space meteoroid missions.

Milton B. Ames, Jr., director of the office's Space Vehicle Div., will hold a meeting June 2 with members of his staff and representatives of other NASA centers to prepare the project for presentation to NASA Associate Administrator Robert C. Seamans, Jr. It is hoped that a decision on the program will be made by July 1.

Details of the new program were learned shortly after the successful launch of the *Pegasus II* meteoroid satellite on May 25. On May 26, NASA reported that the spacecraft had been penetrated by two meteoroids during its first 24 hours in Earth orbit. The hits were recorded on the 0.0015-in. and 0.008-in.-thick aluminum-covered detection panels.

Earlier, the new satellite program had called for launch of two satellites into cislunar space to gather data on the meteroroid hazard prior to a U.S. manned flight to the Moon. Now, reportedly, NASA officials would like to increase the program to cover flights to the planets and asteroid belt.

Langley Research Center last week awarded a $300,000 contract to the Martin Co. for study of a deep-space meteoroid satellite. The cislunar satellite has been studied by Marshall Space Flight Center, which currently directs the *Pegasus* series. If only one program is established to cover both missions, Langley reportedly is favored to direct it.

● **"Lesson in efficiency"**—*Saturn (SA-8)* hurled *Pegasus II* into an almost perfect Earth orbit at 2:35 a.m. EST on May 25.

The lift-off followed a perfect countdown, unmarred by the minor technical problems that plagued ground support equipment during previous *Saturn* launches.

One minor component was exchanged May 24 when project officers discovered two EBW's (explosive bridge wires) in the blow-out panel of the ullage rocket lacked soldering. The units were replaced as a precaution even though tests proved they were not short-circuited. A total of 26 such EBW's is supplied by General Laboratories Associates, New York, in the integrated *Saturn*.

Dr. George Mueller, NASA associate administrator for manned spaceflight, said the precise liftoff is a significant step toward future rendezvous missions in which such timing will be a key factor.

Dr. Wernher von Braun, Marshall Space Flight Center director, praised the launch "as a lesson in efficiency."

All flight sequences and injection were normal. Orbital parameters were: apogee, 465.9 statute miles; perigee, 314.1 statute miles; inclination, 31.77°; and orbital period, 97.29 min.

Pegasus II's orbital life is predicted at 1,200 days, or more than three years.

● **Saturn firsts**—*SA-8* chalked up two firsts—the first time the Chrysler-built S-I stage was used and the first time a night launch was attempted.

The early-morning launch window was required because *Pegasus II* will transmit on the same frequency as *Pegasus I*. The early launch put *Pegasus II* 120°, or one-third of an orbit apart, from *Pegasus I*, launched Feb. 16. ■

Chinese Nuclear Threat Pushes Studies of Nike-X Options

CLEARER INTELLIGENCE information about the potential Red Chinese nuclear threat has prompted the Dept. of Defense to take a new look at possibilities for countering it. AICBM development experts at Army's Redstone Arsenal have recently been directed to review potential ICBM attack situations and come up with the options available to combat them with equipment now being developed in the *Nike-X* program.

At the Pentagon level, tacticians and strategists are agreed that within 10 years Red China will be capable of delivering small numbers of nuclear warheads against the United States. By small numbers they mean quantities greater than 20 or several dozen—possibly 30 to 50. While the delivery method during the next decade is almost certainly limited to aircraft, for the first time the Pentagon is convinced that after about 10 years, certainly before 20 years, Red China will be able to use ICBM's in a relatively "primitive" nuclear attack.

● **Decision near?**—Many observers are convinced that Secretary McNamara is rapidly approaching the point where he will order limited deployment of an AICBM system that will incorporate the *Zeus* anti-missile missile with limited versions of the phased-array radars (MAR and MST) developed in the *Nike-X* program. *Zeus* has been proclaimed an equal and essential partner with *Sprint* in the *Nike-X* system. First deployment of a system equipped to counter a "primitive" nuclear threat could involve *Zeus*, or *Sprint*, or a combination of both. Best bet is that first deployment will feature *Zeus*, along with limited versions of the two *Nike-X* phased-array radars in a system designed for a thinner defense of a larger geographic area than would have been protected by the more sophisticated optimum *Nike-X* system. Such a minimal system might be procured for $8-10 billion.

Recent testimony before Congressional committees has made much of the "building-block" nature of *Nike-X* system design. Thus *Zeus*, designed to counter an unsophisticated, "thin" nuclear attack with few and primitive decoys, would be used with improved radars enabling the system to intercept a greater number of targets simultaneously.

According to the current DOD line, money spent in activating this minimum system wouldn't be wasted, since the *Sprint* atmospheric intercept capability could be added to the initial system later and the radars could be adapted for more sophisticated threats without discarding initial installations. DOD is now on the record, billing *Nike-X* as a system that can grow by accretion, almost indefinitely.

GAO Contracts Policy Is Criticized

House committee chairman Holifield concerned that defense firms may suffer during interagency disputes; Bannerman gives Navy views

FEAR THAT CONTRACTORS are damaged while Government agencies resolve disagreements among themselves over disposition of contracts is expected to lead to recommendations by the House Military Operations subcommittee to amend or modify some practices by the General Accounting Office.

Chairman Chet Holifield (D-Calif.) said in continuing hearings on the effect of GAO and its practices that he was concerned defense contractors were the ones who are caught in the middle of disagreements between GAO and the services or DOD.

"It often becomes a struggle between lawyers to the detriment of contractors," he said. He added that it was his view that contractors have a right to expect one voice from the Government.

The purpose of the committee's investigation, he said, is "to resolve the differences between these Government agencies so that the operation of Government becomes more efficient." One of the points repeatedly alluded to during the sessions has been the necessity for speeding up GAO actions on cases. "Justice long delayed is justice denied," Holifield quoted.

Details of a new revision to the Armed Services Procurement Regulation (ASPR) regarding the lease or purchase of electronic data-processing equipment were released to the committee by Assistant Secretary of the Navy Graeme Bannerman. The GAO has been battling for purchase by the Government of computer equipment to be furnished defense contractors from a central pool.

The new revision, in an attempt to compromise the many objections DOD has to GAO's suggestion, will limit rental costs under CPFF contracts and provide guidelines for fixed-price-type contracts. Limit will be the amount that the contractor would be allowed if he were the owner of the equipment and the Government determined that it would be cheaper to purchase it.

● **Sharp testimony**—Bannerman, who is a former procurement chief in the office of the Assistant Secretary of Defense, told the committee that the Navy Department has "substantive differences" which he hoped the committee's investigation would help resolve.

Echoing some of the comments of Assistant Secretary of Defense Paul C. Ignatius, Bannerman said that he was concerned that some of GAO's recommendations, if followed, would affect the contractors adversely—"making it difficult for contractors to know with assurance the extent to which the Government considers itself bound by its agreements."

Bannerman disagreed with GAO policy on voluntary refunds, which GAO often recommends be asked for when a contractor accrues what GAO terms an excessive profit. However, the Assistant Secretary said that such requests should never be made "simply because an after-the-fact audit suggests that the Government contracting officer exercised poor judgment when he negotiated the contract."

● **Technical data case**—An example used by Bannerman to illustrate disagreements with GAO was a case in which the Navy paid Westinghouse Corp. $1 million for a technical data package to enable the transfer of the manufacturing of spare parts for the J-34 aircraft from Westinghouse to Pratt & Whitney.

GAO disallowed the payment, saying that the Navy should not be paying for information it had already purchased. However, Bannerman pointed out, the preparation of technical data in such a package had never been provided for. In addition, the time factor made obsolete some of the drawings the Navy did own. Westinghouse also made available its staff and production processes to Pratt & Whitney as part of the information contract, Bannerman said.

"This contract was fully performed by Westinghouse in accordance with their agreement and we believe that they are entitled to payment." Bannerman said.

● **Pricing**—Bannerman also cited differences with GAO over what constitutes competition adequate to support an award without cost analysis and negotiation. In one instance, he said, the Navy advertised for bidders for an aircraft carrier, and awarded the contract to the lower of the two bidders responding. The amount quoted by this contractor was $1 million less than the Navy's estimate for the job, based upon its previous experience with aircraft carriers.

However, GAO has drafted a report contending that the Navy should have known that adequate competition was not available and that procurement should not have been awarded without cost analysis and price negotiation. Bannerman said the Navy does not understand what facts GAO used in reaching its conclusion that the Navy was overcharged.

This points up a basic and continuing disagreement, Bannerman indicated, on what is "adequate price competition" and when DOD should price on the basis of an analysis of cost estimates versus awarding to the low bidder.

● **Government interference**—Bannerman also expressed concern that GAO has recommended certain actions "that would involve the Government in decisions which should normally be the functions of private management." He added that these recommended Government actions could have an adverse effect on the contractors' performance thereafter.

An example Bannerman cited was one in which GAO charged that the Government should have bought certain automatic flight-control systems directly from a subcontractor rather than going through a prime contractor. He pointed out that there was technical difficulty with the system which the prime contractor took responsibility for and had the competence to have corrected. Thus, the Navy felt it would have been unwise to break out the equipment earlier.

Bannerman explained that it is GAO's concern that the prime contractor's markup—overhead and profit—on subcontracted work should be avoided. Thus, it recommends that the Government should independently buy and furnish more and more of the equipment components.

"In this way prime contractors would approach becoming mere assemblers and would have a progressively lower responsibility for the quality of the total equipment and its design," Bannerman said. He declared that DOD's view is that recent GAO reports have recommended going "much farther in this direction than is in the best interest of the Government." ■

Final Project Fire Launch Rated Complete Success by NASA

First data study indicates Apollo heat shield design is sound; telespectrograph that failed in first shot performs as planned; re-entry near Ascension was 'in pickle barrel'

CAPE KENNEDY—Project *Fire* officials say the two-shot program completed with a launch here May 22 appears to have been a 100% success—bearing out theories applied in design of the *Apollo* heat shield and proving that no changes in the design are necessary.

The second launch, originally scheduled for May 4, took place at 4:55 p.m. EST May 22 from Pad 12. It had been postponed twice because of technical difficulties and several more times because of cloudy weather in the re-entry area near Ascension Island which would have prevented vital camera tracking.

The 220-lb. re-entry package was crammed with instruments intended to measure convective and radiative heat that would be experienced at re-entry by an *Apollo* spacecraft returning from the Moon.

● **By the numbers**—At a post-launch briefing NASA officers said the *Atlas D* booster performed nominally and sent its payload on its plotted ballistic trajectory. The separation of the spacecraft, its 20-minute coast, the spin-up stabilizing it at 180 rpm, velocity package separation, X259 Antares motor burn and separation all occurred like clockwork, judging from preliminary data. The vehicle achieved a velocity of better than the nominal 37,000 ft. per sec., although "probably less" than the 37,890 fps of the first Project *Fire* craft on April 14, 1964.

Radar and telemetry tracking was good, except during the predictable blackout period, and indicated that re-entry was accomplished "in the pickle barrel."

Project officers were especially pleased that the re-entry package was acquired by the telespectrograph, which failed to track from the ground during *Fire 1*, when only the on-board gas measurements worked.

● **Key data gained**—Measuring the compressed air directly in front of the heat shield—known as the "hot gas cap" was one of the project's prime objectives. Confirmation or rejection of the *Apollo* spacecraft design hinged upon it.

The gas cap, producing brilliant light at re-entry speed as its temperatures soared to 20,000°F, was observed visually from Ascension Island, from 300,000 ft. to the horizon, and reportedly was brighter than on *Fire 1*.

Officials said viewers on Ascension even observed the melting of the beryllium layers which, with thermocouples, constitute calorimeters measuring the amount of heat absorbed from the hot gas cap, and the ablation of the phenolic asbestos layers that protected successive calorimeters in *Fire's* "layer cake" construction.

Weeks will be required for thorough study of results of the shot, but officials expressed confidence that enough good data were received to make it a complete success.

Dr. Milton Ames, director of the space vehicle division of NASA's Office of Advanced Research & Technology, said in a question-and-answer session that future re-entry bodies would study the heat environment in the Martian atmosphere, at returns to Earth in configurations other than ballistic, and perhaps at increased speeds of 55,000 fps. None of these experiments at present has funding.

He touched on the *Scout* re-entry program in which "heating in the turbulent boundary layer" at lower velocities will be examined. About $5 million is available for this Langley Research Center project in NASA's Fiscal Year 1966 budget. He said the payload, much more slender than *Fire*, could be launched from Wallops Island, Va., in the direction of Bermuda.

Principal contractors in the *Fire* program are: Republic Aviation, re-entry package; LTV, velocity package; and General Dynamics/Astronautics, launch vehicle and systems integration. ■

ATLAS D lifted off Pad 12 at Cape Kennedy at 4:55 p.m. EST May 22 carrying 200-lb. Fire package on 5,000-mi. flight.

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NASA Associate Administrator Dr. Robert C. Seamans, left, and ERC Director Dr. Winston E. Kock look out from temporary headquarters to site upon which center will ultimately be located. Construction of permanent facilities is to begin next spring.

SPECIAL REPORT: ELECTRONICS RESEARCH CENTER

The space environment of manned missions to Mars, probes to the Sun and other planets, and long-duration Earth-orbital missions requires electronic systems far beyond the current state of the art. Communications systems with the ability to transmit over hundreds of millions of miles, components that will operate for years rather than months, and guidance systems with incredible accuracy must be developed if the U.S. space program is to move beyond the Moon.

NASA's new Electronics Research Center is charged with the unique mission of developing those systems. The center was first established in September, 1964, and ERC officials have just completed plans for its future research program and its master facility plan.

Missiles and Rockets, in this special report, surveys ERC's plans for achieving its mission.

Part I details its future plans and programs.

Part II covers the advanced technology projects in its five major research divisions.

Part III examines its ten laboratories.

New Center Will Produce Prototype Hardware as Well as 'Paper R&D'

Plans are proceeding for construction start next spring; $5-million rural site for sensitive testing now planned in addition to 11 urban labs

LONG-RANGE PLANS for NASA's Electronics Research Center disclose that there will be a considerable amount of prototype hardware development in addition to its more publicized paper research work.

This will be particularly true during 1967 in the areas of guidance, components and control systems.

The potential and planned capability in the prototype area was learned from top-level ERC officials who—despite urban renewal problems and the criticism of some Congressmen—are moving ahead with plans to begin construction of permanent facilities next spring. An administration and engineering building and two laboratories will be first on the construction schedule.

In the guidance area, prototype hardware will be developed for such systems as rendezvous and docking radars with an acquisition range of 200 miles, planetary horizon scanners, solid-state star trackers, dynamic planet trackers, and planetary landing radars.

In control, a multiple-color television display system for attitude control using only a single cathode tube and a fluidics system will be developed.

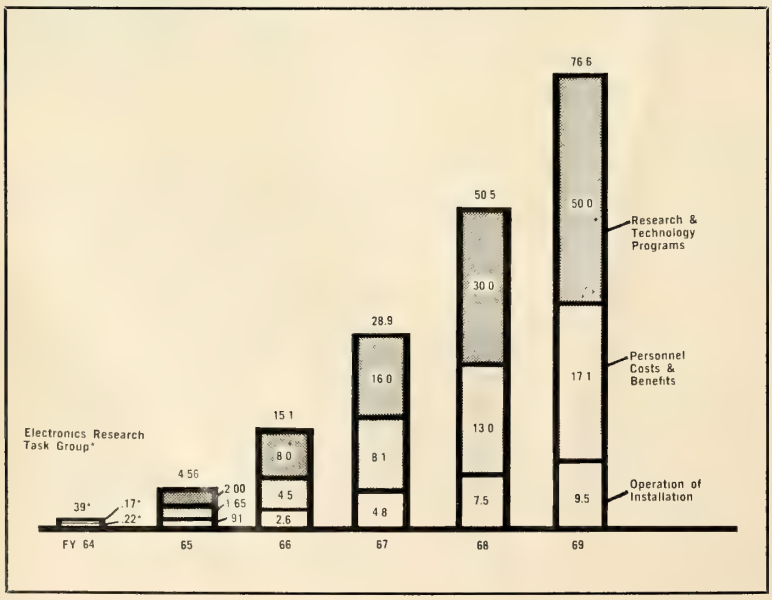
Lasers, deep-space communication equipment and many other systems will also be developed by ERC through contracts with industry and universities. (For details, see Part II of this report.)

ERC is starting slowly with only a $2.5-million R&D budget in FY '65. The funds will be used for about 30 separate research contracts. By FY '69, however, its total operating budget will jump to more than $75 million, and the center will be doing twice as much electronics research work as all other NASA centers combined.

The center was established by NASA to meet the future electronics requirements of the space age. Deputy Director Dr. Albert J. Kelley points out that in order to do this, "We have to develop a whole new breed of components and we can only do this with research. We look upon ourselves as a catalyst between the large electronics industry and the university community and the requirements of the future U.S. space program," he continued.

ERC Director Dr. Winston E. Kock believes that "The center will fill the Space Agency's need for a strong in-house capability in electronics and it will constitute a space-oriented research group which will be able to assess quickly the value of new scientific discoveries in space applications."

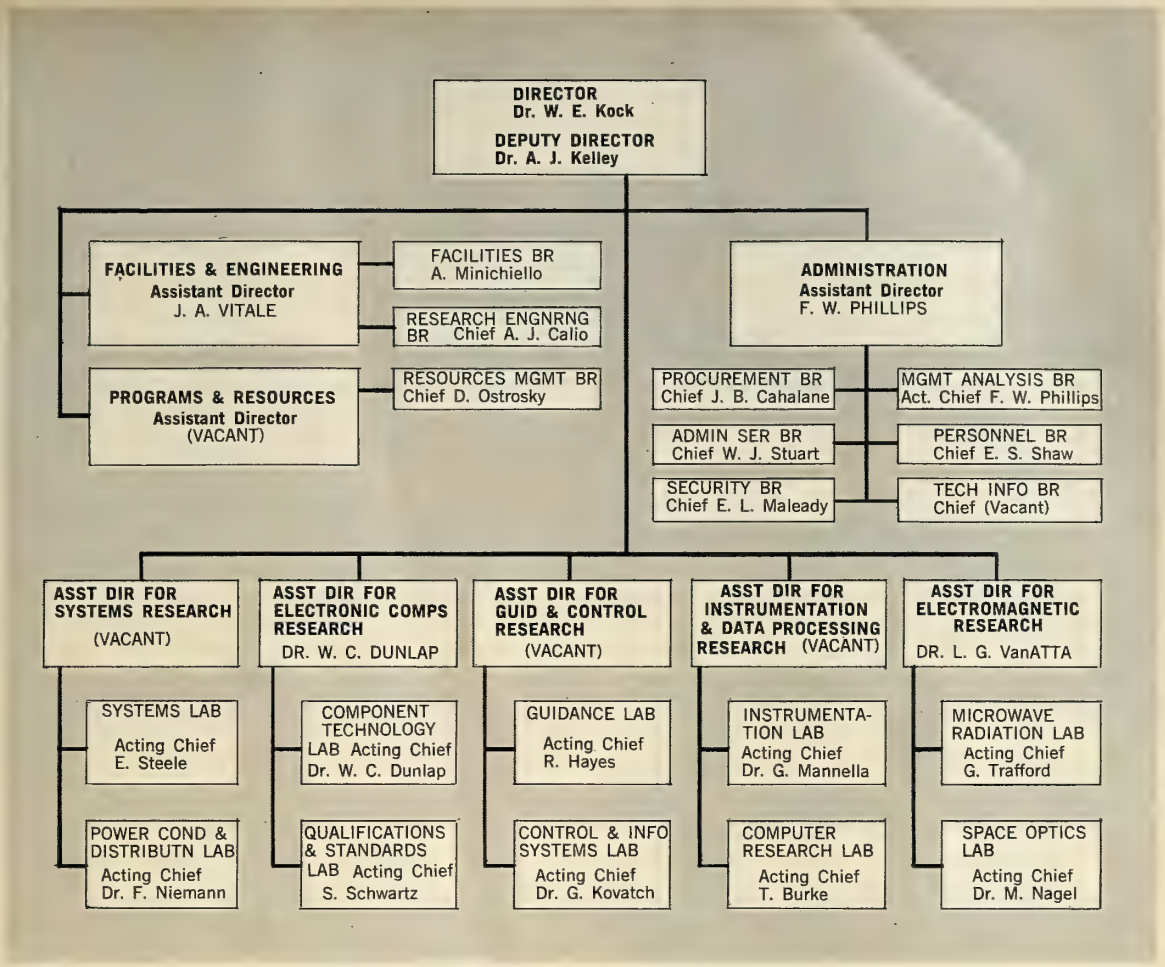
FUNDING REQUIREMENTS for space agency's Electronics Research Center in millions of dollars.



● **Controversial beginning**—ERC was first proposed by President Kennedy in the Fiscal 1964 budget, which went to Congress in January, 1963. When some members of Congress questioned the need for such a center, as well as the selection of the Boston area as its site, further study of the project was ordered. In January, 1964, NASA presented a detailed report on the center to Congress. As a result, first substantial funding was authorized by Congress in the space agency's FY '65 budget.

Other roadblocks to development of the center soon appeared, however. A group of industrial firms with existing plants in Kendall Square, Cambridge, Mass., where the center is to be built as part of an urban renewal project, filed an injunction to prevent acquisition of the site. Subsequently, a Massachusetts court ruled that such suits could not be filed until the U.S. Urban Renewal Administration had established that the site was an eligible area for redevelopment.

On April 26, 1965, URA announced that a study initiated in December, 1964, had found that the area was a "feasible" urban renewal site. It also announced that it would spend $401,000 to begin surveying and planning activities for the project. Responsibility for the survey, under URA rules, was del-



ELECTRONICS RESEARCH CENTER organization chart.

egated to the city of Cambridge, and its officials announced that public hearings would be held before seeking final local and URA approval for the project.

While it is expected that further law suits may be filed in an attempt to block the project, Cambridge officials have informed NASA that they do not expect litigation to hold up the project. They have also informed the space agency that they expect to turn over the site to NASA in the spring of 1966. As a result, ERC officials are moving ahead with plans to begin construction of the center early next year.

● **Construction**—The master plan for the center will be presented to ERC in June, 1965. It was prepared as a joint venture by the architectural firms of Edward Durell Stone, Giffels & Rosetti and Charles A. McGuire & Associates. Other firms involved in the early planning for the center also included Jackson & Moreland, which studied the requirements for laboratory equipment. The master plan will contain detailed designs of the laboratories and buildings that will make up the center, as well as plans for future requirements.

As soon as the master plan is received by ERC officials, they plan to begin engineering design of three facilities—the Engineering and Administration Building, the Qualification and Standards Laboratory and the Component Technology Laboratory. Construction of all three would then begin early next year with FY '65 funding of $10 million.

ERC's FY '66 construction request —approved by the Senate but denied by the House—calls for funding of three more labs: Microwave Radiation, $3 million; Space Guidance, $3.9 million; and Space Optics, $2.1 million. If a joint House-Senate conference committee approves the funds, engineering design will begin early in FY '66, with construction to start early in calendar 1966.

Two other laboratories, Systems and Computer Research, were dropped from the space agency's FY '66 budget before it was presented to Congress and starts on those facilities now will not be made until FY '67.

A start on the Systems Lab will require $2.5 million and the Computer Research Lab will need $2.5 million for design and initial construction work.

Three other laboratories are also scheduled for inclusion in the FY '67 budget, but some slippage in this schedule may be forced if Congress reduces the FY '66 request. Preliminary costs for the first year for those labs are Control & Information Systems, $3.5 million; Instruments Research, $3.5 million; and Power Conditioning and Distribution, $2.1 million.

Current plans, according to ERC Director Dr. Winston E. Kock, envisage that each laboratory will be housed in a separate building. This probably will also mean that there will be competitive bidding on the construction contract for each laboratory.

TEMPORARY ERC headquarters at 575 Technology Square, Cambridge, Mass. Construction of permanent facilities is expected to begin in Spring 1966.

ERC also plans to use the modular approach to the construction of the labs. This will require incremental funding in Fiscal Years '67, '68 and '69. (For details of that funding, see the special laboratory equipment schedule in Part III.)

• **Research work already under way**—The delay of about a year in its construction schedule caused by the urban renewal problem has not caused ERC to shrink from its responsibility to perform the research needed to develop electronic systems for launch vehicles and spacecraft that will be flying in 5 to 10 years.

Temporarily based at 575 Technology Square in Cambridge, ERC officials are busy awarding some 30 study contracts covering problems and advanced technology in its five major areas of research responsibility—guidance and control, components, systems, electromagnetics and instrumentation and data processing.

About $2.5 million from the center's FY '65 R&D budget will be used for the contracts, which are all expected to be awarded by June 30.

ERC's research operations will jump considerably in the next fiscal year when $6-7 million will be earmarked for research—almost all with industry and universities. The total will be divided approximately this way: component technology, $1.25 million; guidance and control, $1.5 million; computer research, $1.5 million; electromagnetics, $1.2 million; and systems, $300,000.

• **FY '67-69 forecast**—A projection of future plans for FY '67 sees a jump in R&D funding to $16 million with about $14 million scheduled to be spent with contractors. This would break down—depending upon NASA headquarters and Congressional approval—into guidance, $2.0-2.3 million; control, $1.5-1.7 million; communications, $3-3.2 million; tracking and data acquisition, $1.35-1.5 million; data handling, $1.55-1.8 million; instrumentation, $1.25 million; and electronic component technology, $1.85 million.

In FY '68, its research and development funding will jump to $30 million. In FY '69, it is projected that $50 million will be required, with $42 million slated for contracts with industrial firms and universities and $8 million for in-house work. At that point, all of the other NASA centers will be doing a total of only $26 million in electronics research. (For details of planned R&D activity, see Part II.)

As for ERC's budget in the early 1970's, Dr. Kelley refused to make a prediction except to say that it probably won't be below FY '69.

In addition to the research paper studies and prototype development, another area that undoubtedly will grow along with ERC is that of flight experiment activities. Some of these are already being studied by center officials and could come to fruition in about two years.

• **The chain of command**—Whether the idea for a research program or project originates at ERC, another NASA field center or another government agency, the command post is still the Electronics & Control Division of NASA's Office of Advanced Research and Technology.

If a NASA field center wants some electronic research done, it writes a work task, which is sent to the Electronics and Control group, headed by Frank Sullivan, at NASA Headquarters. If the task is approved, the group assigns the job to ERC or some other center. If a NASA center or program office asks ERC to perform a certain research task, ERC prepares a program proposal and submits it to the E&C group for approval.

In addition, the ERC program and that of other NASA centers is reviewed by a special Research Advisory Committee—composed of outside experts—which meets every six months to advise the agency of the adequacy of its program. The Technical Advisory Committee, composed of representatives of all NASA centers, also meets four times a year in a continuing effort to set up a good research and technology program.

Despite its comparative newness, ERC has already come up with two procedures unique to the space agency's research work. They are:

1) Laboratory chiefs will not simply monitor industry and university contracts that are awarded; they will manage them. This means that they will work along with the contractor during the time the work is performed rather than sitting back waiting for it to be completed and a final report submitted. ERC officials believe that this will permit them to be constantly aware of the results of the work as well as aid the course of the research to be done at the center itself.

2) In order to better determine the capabilities of firms wishing to do business with them, ERC procurement officials have developed a new procedure called Industry Registration Kit for R&D which will supplement the regular NASA registration forms. (For details, see p. 29.)

In addition to the 10 labs, ERC requires an isolated site in a rural area for sensitive testing. It will contain equipment from four of the labs that will be located at the Center. Its total cost is estimated at $5 million, with $2 million for land acquisition, $550,000 for microwave radiation laboratory equipment, $1.17 million for space guidance laboratory equipment, $560,000 for optical communications equipment, $500,000 for systems laboratory equipment.

The site has not been selected for the auxiliary plant, but an announcement is expected later this year. Several hundred acres will be required. Officials now hope to purchase the area needed with construction funds already approved by Congress. If this is not possible, they plan to try to obtain some Government land.

The center is also going to spend about $1 million on temporary labs to be housed in the basement of its current location. The temporary labs will have enough equipment to make it possible for personnel from each of the 10 laboratory groups to begin their work and perform meaningful experiments and tests.

Total personnel at ERC is expected to grow to 1,000 by the end of FY '67, 1,600 by the end of FY '68 and 2,100 at the end of FY '69, when the personnel complement will reach its peak. ■

Another RD and E capability report from ALLIS-CHALMERS

First 28-volt fuel-cell system to pass 500-hour test at NASA!

Successful completion of this test demonstrated Allis-Chalmers capability to respond to RD & E challenges. The challenge was to fabricate and assemble two 28-volt, 1.8kw fuel-cell systems — subject one system to a 400-hour verification test and deliver the second system to NASA's Manned Spacecraft Center, Houston, Texas, within TWO AND ONE-HALF MONTHS after contract go-ahead!

The challenge was met on schedule. On arrival at MSC, the second system was successfully run by NASA personnel with assistance from Allis-Chalmers for 200 hours.

Next, NASA personnel took over and ran the system without assistance — through the four-segment load profile as specified — for 300 hours. Test time totaled 500 hours of operation under load, exceeding contract requirements and still operating within an acceptable performance range. Tests are continuing.

The test load profile varied from 480 to 1800 watts, a considerably more severe profile than would be expected during actual missions or qualification demonstrations.

Achieving design performance as predicted represents years of work . . . a result of constantly advancing fuel-cell capability:

- First fuel cells in a land vehicle, 15-kw tractor, applied in 1959.
- First fuel cells to successfully pass zero gravity tests, Wright Patterson AFB, in 1962.
- First fuel cells "qualified for space" with the Air Force, in March, 1964.
- First fuel cells to power an underwater vehicle — Electric Boat Division, General Dynamics Star I submarine, in July, 1964.
- First 28-volt fuel-cell system to pass 500-hour test at NASA.

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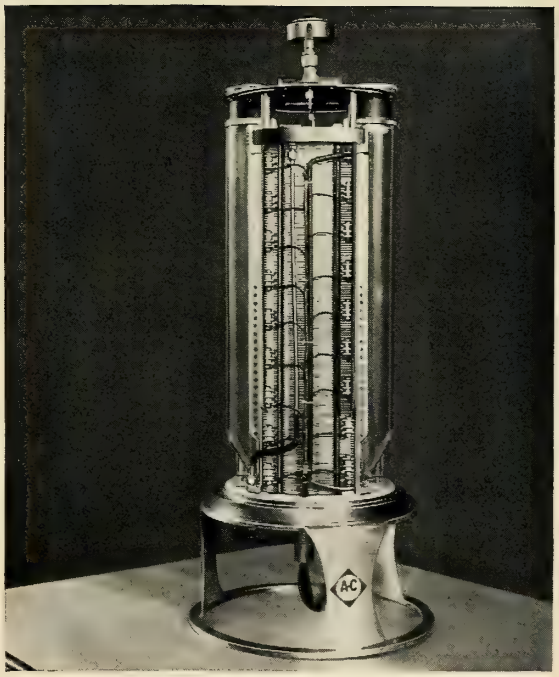
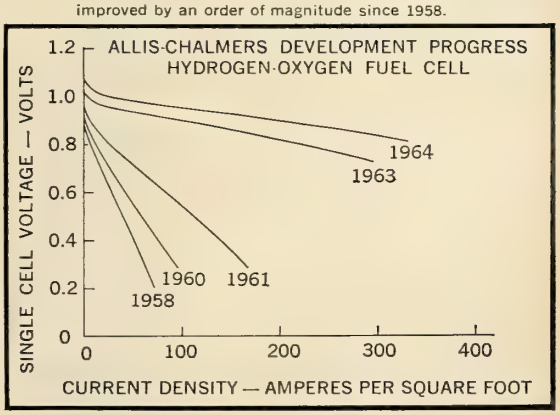


Allis-Chalmers 28-volt, fuel-cell system is the first to successfully pass 500-hour test at NASA.

Chart shows Allis-Chalmers fuel-cell technology has improved by an order of magnitude since 1958.



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Systems Analysts: For assignments in such specialties as: Operational Analysis, Computer System Analysis (software), Mission Analysis, Requirements Analysis, Guidance and Control and Information Processing.

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Research Mission Prompts New Thinking on Procurement Methods

R&D procurement kit being evaluated as supplement to standard registration form; effort has resulted in registration of 2,193 firms

CONFRONTED BY THE requirements of ERC's unique research mission, NASA procurement officials are developing new procedures to better learn the R&D capabilities of firms wishing to do business with the center.

At the same time, they are making an effort to convince the R&D community that they are looking for a national core of bidders and not one restricted to the Boston or New England area.

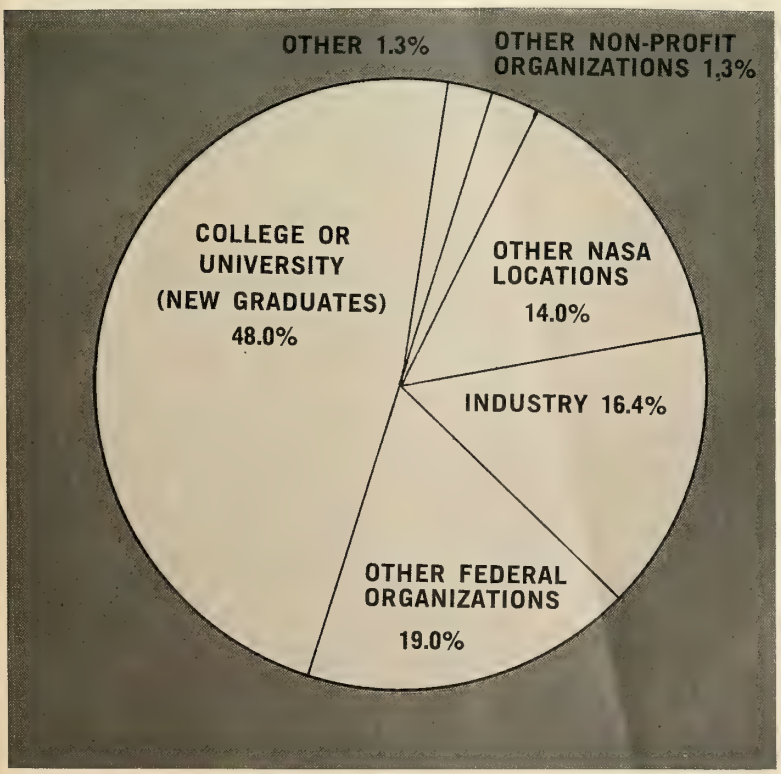
The new method of determining the capability of firms is called the Procurement Registration Kit for R&D.

Current plans call for it to be used by ERC to supplement information obtained from firms submitting NASA's standard registration form, SF-129.

The kit and a cover letter is now being sent to 50 firms as part of a pilot study to determine its effectiveness. Officials expect that a six-month evaluation period will be required to obtain complete results.

If the results are good, the kit will be sent to every R&D contractor currently registered with ERC's Procurement Office and to every new registrant in the future. Procurement officials hope that data obtained from the kits can be used to draw up contractor lists for Fiscal Year 1966 requests for proposals.

Expected sources of professional personnel for ERC.



The idea for the kit stemmed from the inadequacy of the various brochures that companies have sent to the center along with the SF-129. The brochures have provided general information, but ERC officials are interested in demonstrated capabilities attuned to the center's special research interests.

● **Kit contents**—The form letter introducing the kit states that "the functions of our center are to insure that an increased level of research is carried on in those areas of electronics essential to the mastery of space and in those universities, institutes and industries which have the capability for the most advanced research and which are prepared to accept contracts and grants in support of such work.

"In order to meet these objectives to a maximum degree and based upon an analysis of the center's Facility Source System, coupled with valuable comments from industry, we have concluded that it would be mutually advantageous to institute a source system founded upon the correlation of your capabilities and the research areas in which our center will be engaged.

"Form AC-3, enclosed, sets forth the research areas and sub-areas under our center's mission and is designed to serve the dual purpose of increasing your understanding of our center and its function and, at the same time, serving as a checklist profiling your capabilities.

"It is our intention to use the data which you submit as a basis for source considerations incident to specific procurements originating from our center."

The letter adds that the forms should be sent to Edward U. O'Donnell, business advisory specialist.

The kit is composed of the registration card, AC-1, an index of the various research areas in which ERC will be working and their ERC code numbers and form AC-3, which describes the mission and objectives of the work to be done in each research area.

● **Information it seeks**—An example of the information which the kit is designed to obtain in each research area or sub-area follows:

—Name of the company, division and date of the submission of the data.

—Code number and the research area in which the firm believes it has a capability, whether this capability is in basic or applied research or hardware development.

—Names and biographical sketches of key staff members responsible for the research area or sub-area.

—Company performance in the area, including prime contracts or significant sub-contracts (contract or subcontract number, agency or customer, type and dollar amount, period of performance and a summary of performance requirements and objectives, projected and actual).

—Company-sponsored research in the area, including a description of projects, staff facilities employed, existing or planned.

—Significant company papers, technical articles and other presentations (title and synopsis).

—Patents held or pending in the specific area of interest.

The sample information sheet ends with this note: "Our procurement office plans to file under the appropriate code number in your facility file each letter of interest submitted by your company in response to a specific synopsis appearing in the Commerce Business Daily. The quality and detail of letters of interest cannot be overemphasized."

The kit was prepared by ERC procurement office chief James B. Cahalane and industry assistance advisor and small business specialist Edward U. O'Donnell. Other members of the procurement office staff are Henry A. Maffee, contracting officer; James C. Mallen, contracting officer; John F. O'Brien, procurement analyst; John J. Harding, Jr., price analyst; Edward A. Sands, contract specialist; and Robert E. Walsh, contract specialist.

● **Effort rewarded**—The nationwide list of firms bidding on ERC contracts is apparently resulting in valuable information. At the end of April, 1965, a total of 2,193 firms with locations in almost every state in the U.S. were registered with the office. Of the total, 654 classified themselves as R&D companies.

The number of firms registered has grown rapidly and ERC officials are predicting that in five years as many as 7,500 firms may be registered. As an example of the sharp increase, on Aug. 30, just before the center was established, only 831 firms were registered with ERC's predecessor, NASA's Northeastern Contractiig Office. By the end of September, the number had grown to 918; October, 1,312; November, 1,466; and December, 1,542—of which 417 were R&D firms. The number jumped to over 2,000, with 620 R&D firms, by the end of March.

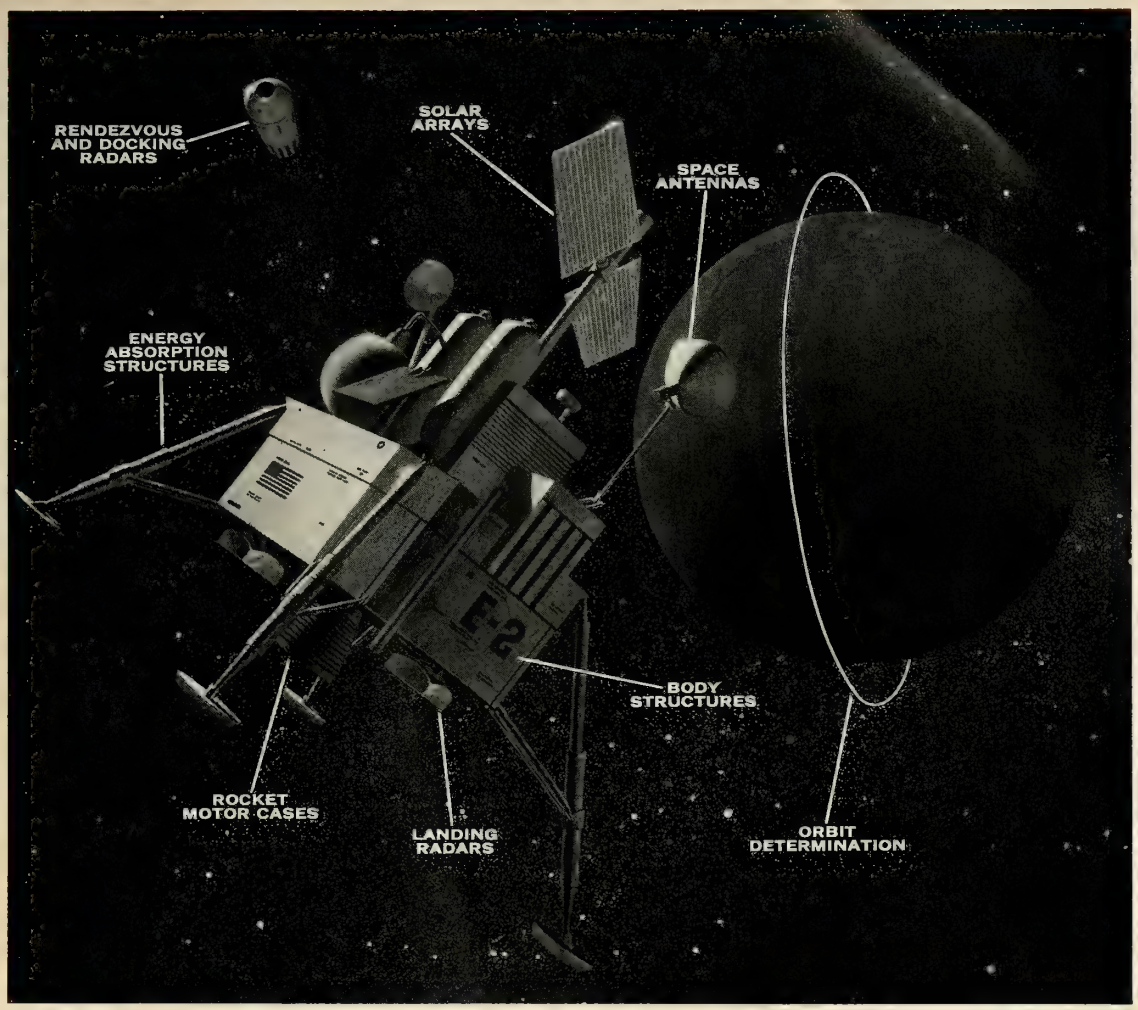
ERC will use the same regulations, manuals and official forms—with the exception of the registration kit—as all other NASA centers. Its contracting, at least in its early formative years, will be almost strictly cost-plus-fixed-fee. This is contrary to the trend at other NASA centers, where incentive-type contracts are being used to an increasing extent. ERC's research study contracts do not lend themselves well to the use of incentives. ■

FY '65 R&D Procurement

CONTRACT NO.	CONTRACTOR	AMOUNT	DESCRIPTION
NAS 12-1	North American Aviation, Inc.	$ 45,000	Monitoring technique physiological variables
NAS 12-2	Wheeler Labs., Inc.	$ 50,000	Macroscopic optical waveguide & opitical component research
NAS 12-3	Northrop Space Labs.	$ 45,000	Short-wavelength radiation detector
NAS 12-4	Autonetics Division of North American Aviation, Inc.	$ 69,000	Process techniques to study integrated circuits
NAS 12-7	AC Spark Plug	$ 89,000	Space vehicle guidance and navigation parametric studies
NAS 12-11	Geophysics Corp. of America	$ 27,000	Ionospheric simulator survey
NAS 12-12	Jackson and Moreland Division of United Engineers	$285,000	Development planning data ERC laboratories
ER-330	Fluid Amplifier Associates, Inc.	$ 2,500	Fluid amplifier systems

PROCUREMENT REQUEST NO.	DESCRIPTION
ERC/R&D 65-7 Hughes	Thin-film space-charge-limited triode
ERC R&D 65-11 AIL-Cutler-Hammer	Sub-millimeter power measurement technique
ERC/R&D 65-12 Douglas	Trace contaminant measurement technique
ERC/R&D 65-13 Westinghouse	Design and construct integrated circuits
*ERC/R&D 65-14 Gen. Precision	Study of current multiplication effect in photoconductive materials
ERC/R&D 65-10	High-temperature, thin-film active devices
ERC/R&D 65-15	Study of lunar, planetary & solar topography techniques
ERC/R&D 65-16	Develop & define concepts for reliable control sensors for use in space vehicle control systems
ERC/R&D 65-17	Artificial intelligence techniques for spacecraft control problems
ERC/R&D 65-18	Research to study radiation effects on laser performance
*ERC/R&D 65-19 Bunker-Ramo	Hollow-cathode plasma penetration study
ERC/R&D 65-20	Study of electromagnetic guidance for space docking
*ERC/R&D 65-21 Martin	Continuation of an experimental millimeter & submillimeter wave spectroscopy research program
ERC/R&D 65-22	Study of millimeter bulk semiconductor effects
ERC/R&D 65-23	Ultra-reliable spaceborne computers
ERC/R&D 65-24	Perform research on critical problems associated with unconventional inertial gyroscopes
ERC/R&D 65-25	Perform research on critical problems associated with unconventional inertial gyroscopes
ERC/R&D 65-26	Research on devices for fluid control system
ERC/R&D 65-27	Research to develop a mathematical model of the human operator involving certain higher cortical functions
ERC/R&D 65-28	Recognition and transmission of video patterns
ERC/R&D 65-29	Study of spaceborne memory organization
ERC/R&D 65-31	Attitude control systems
ERC/R&D 65-32	Research on the design of adaptive control systems
ERC/R&D 65-45	Solid-state integrated microwave circuits
*ERC/R&D 65-44 Analytical Mechanical Associates	Analytical optimization of low thrust guidance
*ERC/R&D 65-46 Rensselaer Polytechnic Inst.	A study of reliability in microcircuits

* Negotiations to be conducted only with source indicated.



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Guidance, Control Studies Under Way

Guidance Lab could become important center for experimental hardware development; work to date being done out of house

RESEARCHING OF NEW concepts, components, and systems applicable to future NASA guidance and control requirements for spacecraft, some surface operations, and advanced ground test and checkout will be carried out by the two laboratories that make up ERC's Guidance and Control Div.

Dr. Robert C. Langford, former head of General Precision, Inc.'s Aerospace Research Center, has just been named to head this division, which includes the Guidance Lab (GL) and the Control and Information Systems Lab (C&ISL). The labs are currently headed by acting directors Richard Hayes (Guidance) and Dr. George Kovatch (Control).

While both laboratories are already actively supporting, or preparing to support, out-of-house study efforts, the GL, in particular, could grow into one of ERC's larger repositories for experimental hardware development.

Guidance Laboratory

Work in the GL is broken down into four major categories—inertial reference sensors and systems, navigation techniques and displays, electromagnetic sensors and techniques, and guidance theory and trajectory analysis.

In the inertial area, GL will put forward a strong initial research effort in unconventional inertial sensors, low-g-level accelerometers, and strapped-down guidance systems. The first of these two areas will be started with FY '65 funds and no doubt will continue into FY '66 and possibly beyond. The strapped-down work is expected to get started with FY '66 funding.

The unconventional sensor research is described as "a very serious effort" by acting director Hayes. ERC got 13 responses to its first RFP in this area, a project that brought ERC scientists quickly up to date in the field. Two of the 13 approaches are expected to be selected for ERC support, with the decision expected shortly. Insiders say that the electrostatic gyro (ESG) and laser gyro (M/R, Oct. 7, 1963, p. 68), will get the nod. GL scientists report close liaison with the Air Force, which has heavily supported much of this research in the past (M/R, Feb. 18, 1963, p. 24), in order to avoid potential overlapping.

While both laser and ESG devices have had support in the past, ERC scientists say that the ESG still has some problems for space use, mostly in the areas of suspension, torquing, and direct angle-cosine readout. The laser research is expected to be directed at solving the so-called "lock-in" problems associated with loss of frequency during operation. Attempts will be made to measure Doppler frequency shifts at rates below 100 cps.

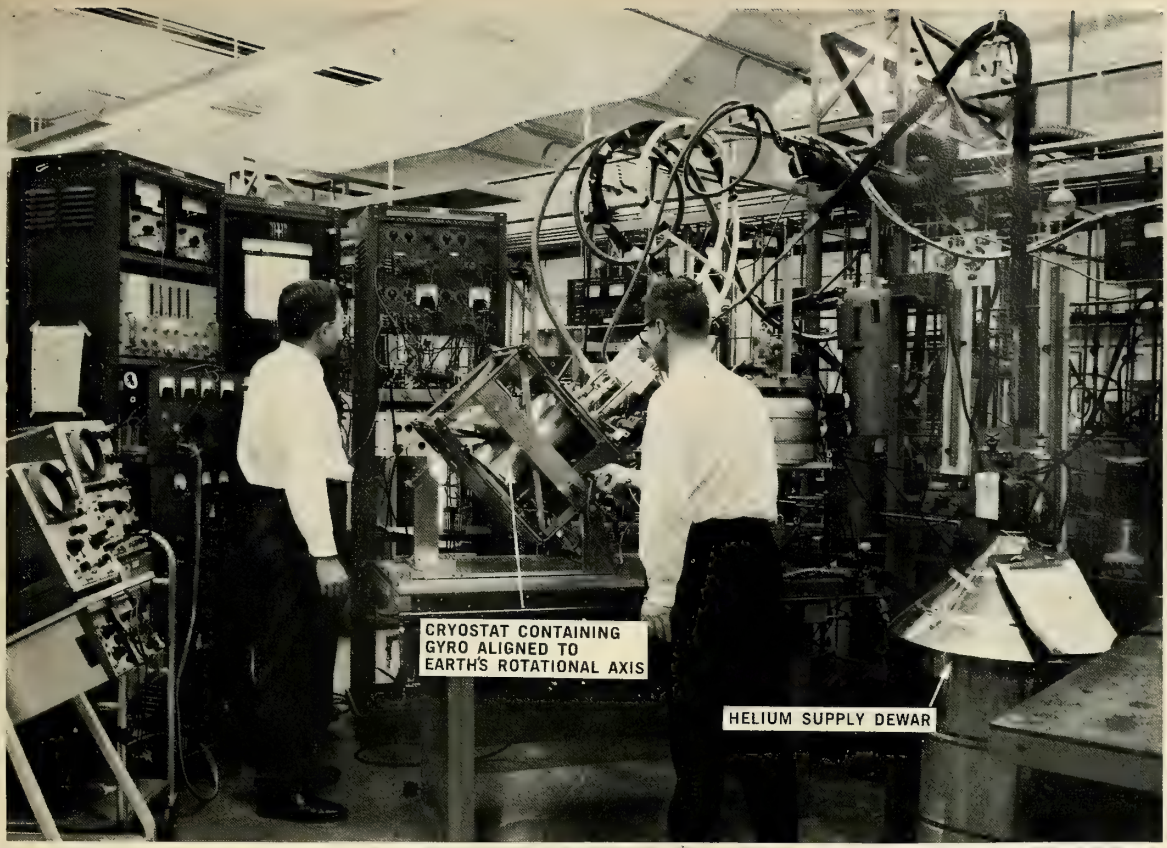
● **Missions of '70's provide drive**—The major impetus for improved gyro reliability and performance is the expectation within NASA that planetary missions of the late 1970's will demand gyro drift rates limited to about 0.0001 degree per hour (0.1 degree per hour is about the present capability) and mean-time-before-failure durations of 1,000,000 hrs. (current MTBF levels are reportedly 1,000 hrs.).

The attempt to fully explore the potential of some of the unconventional gyros (other techniques, such as the nuclear magnetic resonance device and cryogenic gyro, may also be researched further in addition to the ring lasers and ESG's), and the decision to pump more funds into gyro bearing material research is dictated by these growing requirements.

The gas bearing research will be aimed both at developing techniques to avoid gyro failure with a system power loss, and at developing improved bearing stiffness for use in strapped-down, high-slew-rate systems.

ERC Personnel

	NUMBER OF PERSONNEL EMPLOYED				AUTHORIZED
	JAN	FEB	MAR	APR	1965
OFFICE OF THE DIRECTOR	16	18	17	18	22
PROGRAMS AND RESOURCES OFFICE	19	19	19	19	25
FACILITIES AND ENGINEERING OFFICE	19	18	18	20	28
ADMINISTRATION OFFICE	38	41	44	47	64
ASSISTANT DIRECTOR FOR ELECTRONIC COMPONENTS RESEARCH	2	2	2	2	2
COMPONENT TECHNOLOGY LABORATORY	5	4	6	6	13
QUALIFICATIONS AND STANDARDS LABORATORY	9	11	12	12	17
ASSISTANT DIRECTOR ELECTROMAGNETIC RESEARCH	1	1	2	2	2
MICROWAVE RADIATION LABORATORY	5	5	5	6	8
SPACE OPTICS LABORATORY	3	4	5	5	9
ASSISTANT DIRECTOR FOR GUIDANCE AND CONTROL RESEARCH	0	0	0	0	2
GUIDANCE LABORATORY	4	5	9	9	14
CONTROL AND INFORMATION SYSTEMS LABORATORY	5	5	6	6	9
ASSISTANT DIRECTOR FOR INSTRUMENTATION AND DATA PROCESSING RESEARCH	0	0	0	0	1
COMPUTER RESEARCH LABORATORY	4	4	5	5	10
INSTRUMENTATION LABORATORY	5	5	6	6	9
ASSISTANT DIRECTOR FOR SYSTEM RESEARCH	0	0	0	0	1
SYSTEMS LABORATORY	5	5	6	7	10
POWER CONDITIONING AND DISTRIBUTION LABORATORY	1	1	2	2	4
TOTAL	141	148	164	172	250



LABORATORY testing of MK1 cryogenic gyro at General Electric Co.

• **Super-stable facility**—GL also expects to attack the ground test problems associated with both high-performance gyros and low-g-level accelerometers with a major test facility, which will include a dynamic table leveling system incorporating a gyro-stabilized platform for use as an inertial test bed.

The concept, briefly, involves stabilizing the test stand about two axes with high-precision gyros, possibly similar to those used in *Polaris*. "This seems to be much easier than filling Cambridge with concrete," says Hayes, "and will allow us to test both single- and two-degree-of-freedom gyros on the same test stand. We hope to test gyros down to the required 0.0001-degree-per-hour level and achieve table tilt control to 0.01 arc second." GL engineers say they hope to start the facility with FY '65 funds and that it will take 18-24 months to complete. A six-month feasibility study will be made first.

Other unique testing concepts are being developed here relating to low-level accelerometers, an area that continues to perplex both DOD and NASA scientists, who frankly admit that they cannot test these devices down to the levels at which developers say they can operate (M/R, Dec. 7, 1964, p. 32).

One concept involves use of a gyro mounted on a small, precision centrifuge to provide precise torque inputs to two accelerometers, with an attempt then made to correlate the output of the two accelerometers.

GL has already funded MIT for development of low-level accelerometer measurement apparatus, which ERC engineers say looks promising as a laboratory calibration system. The MIT equipment was scheduled to be installed at ERC this month. Some of the MIT people doing the work will be joining the ERC staff. The MIT system involves a cryogenically filled tank, a floated superconducting magnet, a 1-gram test mass suspended in the magnetic field, flat mirrors on each end of the tank, a light source (possibly a laser) used to apply a known photon force to the mass, and an interferometer system hooked up to measure mass displacement. ERC scientists say the technique, using a laser, may allow measurements down to 10^{-7} or 10^{-8} g.

ERC is interested in testing these devices to levels from 10^{-6} g to 10^{-12} g, a range that, in effect, spans the needs of electrical propulsion systems to precision testing of other inertial components. Testing below 10^{-6} g in the 1-g Earth environment is generally the present cut-off point. Eventually, ERC hopes to develop a prototype system that will go aboard a space station for checkout.

In FY '66, GL is expected to start on research aimed at developing units with 10^{-8} to 10^{-9} g capabilities, hoping to get into the 10^{-12} g regime by 1972.

Contracts are also expected, possibly in FY '66, on the start of a program using nuclear phenomena for velocity sensing, including Mossbauer effect, Cherenkov radiation, and nuclear magnetic resonance. Also, GL will study use of an electrostatic gyro incorporating a mass imbalance technique that would allow the device to be used as an accelerometer.

• **Toward simpler instruments**—GL's interest in strapped-down systems is basically aimed at simplifying the guidance package, a long-stated NASA goal, and increasing reliability through use of fewer moving parts. The lab will investigate gyros and accelerometers for gimballess platforms and may eventually develop a complete prototype system in combination with advanced computation procedures for deep-space guidance. One long-range goal is development of a combined gyro and ac-

celerometer in a single instrument, possibly involving either electrostatic or cryogenic suspension.

Other areas to be supported in inertial systems include application of new microelectric circuitry, advanced microsyn signal generators, and new torque generators and gimbal angle resolvers.

GL navigation efforts are also motivated by a desire to reduce complexity, accompanied by an effort to improve accuracy of manual instruments and time standards.

● **Some major goals**—Toward these ends, there are three major programs that the GL is expected to embark upon. In FY '66, the lab is expected to support study of an all-optical guidance and navigation system suitable for portions of interplanetary missions as a means to simplify guidance and navigation equipments. The lab will also look at strapped-down systems for these applications and support other NASA offices in this area.

A program is also likely in the area of manually operated sextants, with the long range goal being an instrument capable of manual measurement accuracies of better than 10 arc seconds and automatic angular measurement of less than 3 arc seconds. Such a device might have a field-of-view of greater than 7 degrees and a power greater than 9X.

The goal in time standards research is to provide frequency accuracies better than 10^{-13}. GL scientists say Mossbauer-effect devices or atomic clocks may be the answer, but a survey study is likely before the lab gets its program under way.

The lab also will do work in navigation displays, including long-range development of a single instrument to combine G&N data, and improved operator/navigation-computer interfaces.

GL also will support a study on inertial augmentation for advanced unmanned launch vehicle upper-stage guidance, probably for the *Centaur* in particular. This could also include study of a strapped-down system.

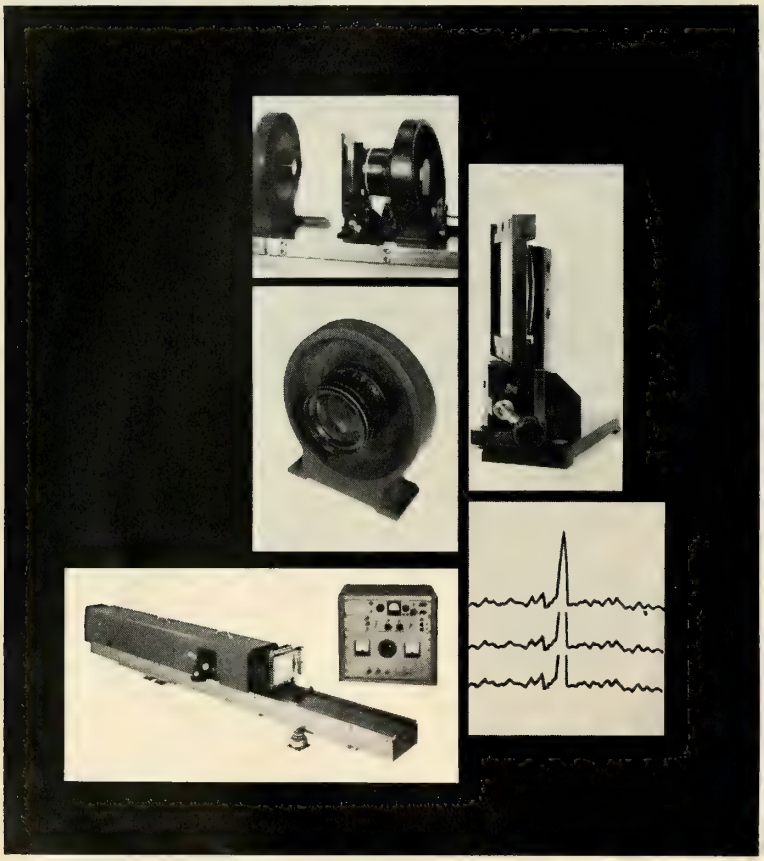
● **Some hardware in the future**—Several important new programs involving hardware development are included in the GL program, for both active and passive electromagnetic sensor improvement.

The lab is expected to launch a long-range program next year involving evolutionary development of spacecraft rendezvous and docking radar with acquisition ranges to 200 n. mi. and ability to effect automatic docking. GL will pick up on a Microwave Lab contract that studied the near-field radar effects that would come into play in this type application.

GL scientists also plan to start efforts with FY '65 funds, both in- and out-of-house, on several areas in the passive sensor field, including planetary horizon scanners, solid-state star trackers, and a "dynamic planet tracker" able to integrate several simultaneous measurements. Emphasis will be on few- or no-moving-part systems and on solid-state design.

For Earth and planetary horizon scanners for the 1970's, the goal is to increase present accuracies of 1-2 degrees to 0.2 degree for altitudes above 1,000 miles, and 0.1 degree for lower altitudes. Also, attempts will be made to move further into the IR region with instruments operating in the 14 to 16- and 20 to 40-micron bands. ERC hopes eventually to develop solid-state star trackers with accuracies within 5 arc seconds. Another probable program involves development of a planetary landing radar able to provide both slant-range and range-rate information.

In the guidance theory and trajectory analysis area, GL will lead off with a contract now being negotiated, which will help generate the thrust-control modes for low-thrust motors in interplanetary flight. Work in this section of the GL largely will be devoted to improving and refining the equations and flight programming associated with interplanetary flight.



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Control and Information Systems Laboratory

Three major tasks make up C&ISL's mission: research into the very-high-performance automatic control systems viewed as necessary to achieve the 0.1 to 0.01-arc second pointing accuracies envisioned for advanced observation and laser communication satellites of the mid-70's; manual control systems and display developments in which man forms an active part of the control loop; and control and information theory. The latter embraces a very broad range of research into adaptive, self-organizing, and other forms of information theory in support of both manual and automatic systems.

Within the area of automatic control of space vehicles, the lab will spend most effort in the active control areas, considering the passive gravity gradient-type systems to be already well researched by the Air Force and other NASA centers. The view is toward systems which will remain in unattended operation between 1 and 3 years and which have inherent capabilities to damp out many of the internal and external perturbations that impinge upon the spacecraft.

The lab will begin funding studies in the application of artificial intelligence schemes to spacecraft control with FY'65 money and will continue these efforts in FY'66 and beyond.

The lab has also issued an RFP in an effort to come up with highly reliable attitude sensors. The lab, in the same development effort, would also like to begin the push for these sensors to exceed present 1.0 to 0.1-arc-second accuracies.

● **Biological control work possible**— Other programs envisioned, possibly beginning in FY'67, involve application of biological control principles to space vehicles.

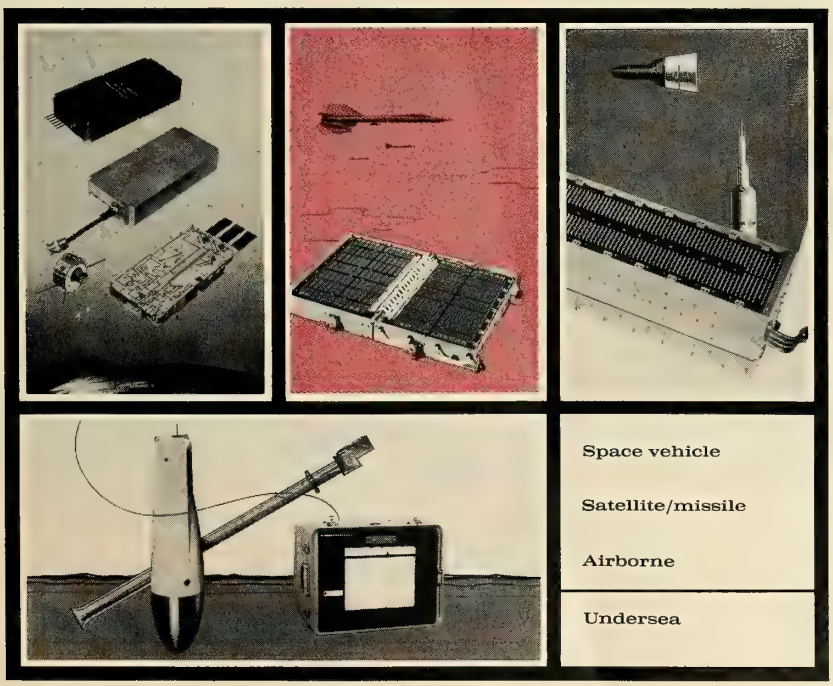
One of the major areas of interest for the lab, and one in which both an in-house and out-of-house program will be developed, is in fluid control systems (see M/R Special Report, Feb. 1, '65). While accuracy of these systems may not be high enough for navigation and guidance applications, C&ISL scientists point out that it may well be suited for attitude control.

The fluidics program is expected to get its major start with FY'66 funds. Work is expected in fluid components and systems, and in compatibility with other sensors. In that connection, a small amount of funding this year will be aimed at research of electro-fluid conversion devices. Scientists here speculate concerning development of a complete fluid system, possibly working in conjunction with a fluid computer. This has been a long-range goal of the space agency for some time.

Also in the fluidics area, research will be supported on instrumentation and displays. The latter will be associated mostly with manual systems, with scientists looking far ahead and seeing some sort of fluid equivalent of a cathode ray tube evolving.

In the manual control area, much attention will be given to continuing research in mathematically modeling the human operator. The lab will also serve as a focal point for new displays associated with manual spacecraft control, ranging into some very esoteric concepts. Research is expected on use of sensory capabilities such as touch, kinesthesia, and the vestibular function. Also, peripheral-vision devices, so-called "heads-up" displays (of interest during re-entry), solid-state devices with improved brightness, and several means of increased use of TV.

One particularly interesting task that should get under way next Fiscal Year involves development of a multiple-color TV for display using only a single cathode ray tube. Major advances would be needed in size, weight, and reduction of the operation to a single gun. ■



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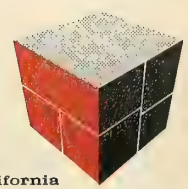

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Component Technology Has 'Core' Role

Qualifications and Standards Laboratory will be first set up at ERC permanent site; Component Technology Lab will seek breakthroughs

ERC'S COMPONENT TECHNOLOGY DIV., consisting of the Components Technology Laboratory (CTL) and the Qualifications and Standards Laboratory (Q&SL), comes closest to the core of ERC's intended role within the space agency—the assurance of high reliability in space electronic components, both in those currently available and in the devices to follow in the next 10 years.

The division, one of three at ERC having directors at this point, is headed by Dr. W. Crawford Dunlap, a former top scientist with Raytheon Co. Dr. Dunlap also serves as acting director of the CTL, pending the naming of the permanent lab chiefs.

The Q&SL is described as the "core laboratory" by top ERC officials due mostly to its role in improving electronic equipment reliability for near-term NASA programs. It will be the first laboratory set up by the Center at the permanent ERC site. The lab, headed by acting director Seymour Schwartz, has already begun contractual operations at the temporary Technology Square site. The CTL will be the second lab in operation at the permanent site.

Engineering design is expected to start in June for the Engineering & Administration Building at ERC, the Q&SL, and CTL buildings. The Q&SL will be funded incrementally each year through Fiscal Year 1969.

The two labs have a combined budget of about $400,000 for FY '65. This is expected to grow to about $1 million in FY '66 and $10 million by FY '69. The Q&SL funding is expected, according to Dunlap, to be spent out-of-house in larger measure than the CTL budget. Schwartz, for example, estimates that 80% of the Q&SL's FY '66 funding will be in the form of outside contracts and grants.

Qualifications and Standards Laboratory

The Q&SL has three major objectives: introduction of higher reliability into presently available microcircuits and sub-systems; techniques and instrumentation to study failure mechanisms of electronic devices, especially silicon integrated circuits; and new microcircuit processing techniques and controls.

There are also several less urgent, but nonetheless important, goals. These include new concepts for specifying microcircuit reliability; establishment of qualifications and standards for these devices tailored specifically to the known NASA mission environments; improvement of component data exchange and central data storage; and generation of advanced concepts for accelerated device testing.

Officials here view these projects as the opportunity to shape electronics reliability specifically to NASA programs and flight environments, whereas earlier developments were largely left to the impetus supplied by the Defense Dept. NASA says its manned missions require possibly an order-of-magnitude improvement over DOD reliability standards.

While improvements are expected in devices, ERC officials are not yet ready to make any pronouncements about generation of NASA-wide specs and parts lists. The caution is primarily due to the existence of pockets of electronic competence built up at other NASA centers and the recognition by ERC scientists that these Centers may remain in the best position to specify certain electronic requirements for mission-related equipments.

- **Work already begun**—The Q&SL has already moved into a fairly widespread research effort both in- and out-of-house.

The tasks begun in recent weeks, or soon to be awarded, using FY '65 funds, represent tasks likely to be carried through for several years, perhaps with different firms or funding levels.

The programs begun with FY '65 funds include a contract just awarded to the Autonetics Div. of North American Aviation, Inc., for studies of improved process techniques for silicon integrated circuits (SIC's). Particular attention will be paid to insulating layer interractions and to instrument development able to observe surface defects. Also, attempts will be made to correlate failure modes with processing variables.

Q&SL has also recently taken over a contract under way since last July with the Librascope Div. of General Precision, Inc., in which studies are aimed at determining the physics of microcircuits failure and reliability with an eye toward verification of failure prediction techniques.

ERC has three university grants in the works in the Q&SL area. One, under way since November, is with Northwestern University, covering high-reliability linear microcircuits using digital techniques. A new grant is being negotiated with MIT for improvement of gyro-accelerometers using cross-correlation techniques to isolate those parameters causing gyro drift. Another university grant is expected to be awarded shortly for a broader study aimed at relating recent microelectronic advances to new circuit design in both monolithic and hybrid circuits for digital and analog applications.

- **Due to begin in FY '66**—Out-of-house work to get started in FY '66, and in many cases to be carried through into FY '67 and '68, includes contracts to evaluate processing techniques for metal-oxide semiconductor (MOS) integrated circuits with both p- and n-type channels. These MOS devices are seen as playing a potentially large role in future electronic systems (M/R, Feb. 3, 1964, p. 52). Similar work will be directed at bi-polar integrated circuits. Additional awards will be made for studies of failure mechanisms related to semiconductor surface properties, including new detection methods and instrumentation. (NASA scientists point out that failure mechanism study of microcircuits devices can involve analysis of samples containing as little as 1 micromicrogram of material.)

Among the major in-house tasks to get started in FY '66 is an important evaluation of conditions influencing leakage current in semiconductor devices. These currents have been reflected

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DR. W. CRAWFORD DUNLAP, former key scientist with Raytheon Co., is chief of Component Technology Division and acting director of Component Technology Laboratory. He says the lab is aiming at "some really pioneering work."

as instabilities, particularly at circuit junctions, where large reverse bias and high-temperature conditions exist. The problem is believed to be caused by still uncertain control of surface-state conditions, primarily thought to be the result of still unperfected passification processes. The problem has reportedly become more critical with the more widely used planar epitaxial circuit fabrication method.

ERC also expects to fund research in the 1966-68 period into new subsystems using integrated arrays of MOS field effect transistors (or bi-polar transistors) for performance of complex spacecraft data processing functions.

NASA will also use in-house funds in FY '66 to initiate research into adaptive circuitry as a means to enhance spacecraft reliability.

Other programs getting underway in FY '66 and having implications both for long-range in-house programs and some out-of-house funding into the 1968-69 period include: continued support of research into failure mechanisms—what they are, how can they be predicted, detected, and isolated; also, there will be emphasis on interconnection problems, particularly metal-semiconductor contracts; and investigation of all micro-circuit bonding techniques, including soldering, welding, and both ultrasonic and diffusion bonding processes. The in-house effort to develop accelerated integrated circuit life testing is expected to get under way in FY '67.

Component Technology Laboratory

ERC's Component Technology Lab, while already in the business of letting contracts, has within its list of objectives many of those tasks with the longest-range payoff potential incorporated into the ERC concept. The work here is more in the basic research category. More of it will be in-house and directed at potentially revolutionizing several different segments of electronic componentry—and eventually system design—during the 1970's.

The work of the lab is broadly broken down into advanced research, materials, microelectronics, device development, and physical electronics. However, within each group there are numbers of individual detailed tasks, some of which are already under way, but many of which will not move into full swing until the lab is installed in the permanent site in about two years and full use of lab equipment can be made.

- **First pacts next month**—CTL will award its first two contracts in June. Both are primarily feasibility studies; however the first award, now in negotiation, will also involve some device development. The contract will be for a thin-film space-charge-limited triode,

seen as one of the most promising new microelectronic devices in terms of speed, size, temperature response, density, and low-noise characteristics. The development of the thin-film device will be an evolutionary one with early phases directed at hybrid devices, eventually moving toward silicon TF triodes and then on to other films of lesser fabrication complexity than silicon.

The second award, for which proposals are now in at ERC, involves study of new high-temperature thin-film active devices able to function in 500° C. environments. The materials are expected to move beyond cadmium sulfide and silicon TF transistors into wide-band-gap materials such as silicon carbide. High-temperature capabilities are needed for various solar and planetary probes.

Thin-film work will get continuing attention in CTL's FY '66 budget also, with particular emphasis placed on materials development. Also work will be sponsored on both active and passive devices, with a strong effort on low-temperature devices. Long-range tasks in this area will include support of research in thin-film resistors, especially nichrome and related metal types; thin-film deposition techniques; and relationships between the band structures of various films, their bulk materials, and conduction properties.

• **Materials to get emphasis**—The materials area, key to better thin-film circuits, is also closely linked to almost every other phase of advanced electronics, and CTL will, beginning in FY '66, support a very broad program of research in such areas as semiconductors, magnetics, and dielectrics, in addition to new means to measure and analyze material properties.

Silicon carbide will get major attention as a high-temperature semiconductor material, but ERC will also devote time and money to new approaches to organic conducting materials. In addition, work on vapor deposition techniques involved in placing one epitaxial layer of compound semiconductors upon another will be researched.

CTL support of other ERC labs, such as space optics and microwaves, in the materials phenomena area is also expected to play a role in ERC's attempt to develop high-speed microwave microelectronics able to operate in the 5 to 20-gc range. Studies of material energy levels and pumping schemes is also expected to aid development of laser modulators and frequency converters in cases where performance beyond the current state of the art is called for.

Research in magnetics is planned in areas important to low-power computer operation, with lithium ferrite materials certain to get a hard look. Research directed at possible substitution of elements such as sulfur, fluorine, or tellurium for some of the oxygen components of current ferrite oxides is also expected to be undertaken.

Dielectric research will be channeled into improvements in the titanate group by zone refinement methods using electron beam heating, and, also, investigation of new refractory materials as perhaps a better insulating layer than silicon dioxide for microcircuits. The CTL program is aimed at longer life for these materials, and lower circuit losses, with the possibility of some early payoff in existing SIC and MOS-type components.

• **Other microelectronic work planned**—In addition to the work in thin films and semiconductor materials research, CTL will also, beginning in FY '66, begin support of other aspects of microelectronic technology. One of the lead items is expected to be study of ion beam implantation techniques for microcircuits to bring control of device machining dimensions to a point where they would be measureable in Angstroms. NASA officials are optimistic about being able to demonstrate this by 1966. Scientists here are generally optimistic concerning use of ion, electron, and laser beam techniques, possibly with materials other than silicon, for future IC fabrication.

Further along, for specific NASA missions in the 1969-70 period, other projects are aimed at coming up with a very-high-speed, high-temperature microcircuit module, with initial work in gallium arsenide, and at development of high-temperature microelectronics in combination with high-radiation resisitivity, something that scientists here say may involve looking at vacuum-tube approaches to microcircuit design.

Dr. Dunlap also told MISSILES AND ROCKETS that the CTL expects to do "some really pioneering work in molecular electronics." This is an area where some premature claims have been made and which is still several years from realization, many observers say.

In order to further work brought forward in some of the more basic research areas, CTL will also sponsor development of promising individual devices growing out of the CTL research, or other ERC labs, or NASA centers. Semiconductor devices are expected to present the most frequent type of development since most of the NASA electronics capability is designed around them. However, Dr. Dunlap also notes that there will be important efforts made in the millimeter tube field and in the combination of microelectronics with various spaceborne transducers.

• **Millimeter tube work**—The millimeter tube effort is reportedly the only definable tube development goal at this point, and ERC's microwave lab has already asked for CTL assistance in this area. There is growing support for use of millimeter wavelengths for a wide range of space communications at the available atmospheric windows (M/R, Sept. 7, p. 38). CTL will look at transmitting tubes and energy-controlling devices such as ferrite circulators. Also, improved machining may play a part in building better millimeter tubes. A long-range task in the vacuum tube area involves development of a submillimeter 250-mw signal source operating at 450 gc.

Other long-range CTL vacuum tube programs include refinement of electrostatically focused klystrons to bring operation from the present 2,000-mc range up to X-band with power output of about 20 watts.

The coupling of microelectronics to mechanical sensor elements could involve such things as direct gyro gimbal readout from gimbal-mounted microelectronics or direct combination of telemetry components with sensors.

The other major potential area of CTL device development activity is in optics and display, where scientists see new optical components, such as GaAs diodes or lasers, as potentially improved output devices, computer elements, or in scanning arrays where electronic signals can be used to control light beam direction.

• **Physical electronics**—CTL's work in what it calls physical electronics is centered in non-solid-state devices and basically involves study of electron and ion flow in vacuums and plasmas and their interraction with each other and with solid surfaces. The work has very basic application to widely varying requirements for increased understanding and control of sputtering phenomena important to microelectronics fabrication and to lower-noise, more efficient millimeter tubes. To the latter application, CTL is expected to support efforts to come up with the long-sought-after "cold-cathode," which exhibits stability and efficient operation at room temperatures and below.

CTL's program of advanced research will include several areas, but will focus major attention on low-temperature research, again seeking new reliability gains for componentry. In particular, a strong program is expected in the area of superconducting semiconductors and in tunneling devices based on flux quantization phenomena.

Programs now viewed as meriting support in the field of quantum electronics, where very-long-range goals are envisioned, include studies of the band structures of silicon and silicon carbide, a closer look at the electrical properties of high-purity gallium arsenide, and investigations of solid-state plasmas, an area in which scientists feel entire families of devices could develop. ■

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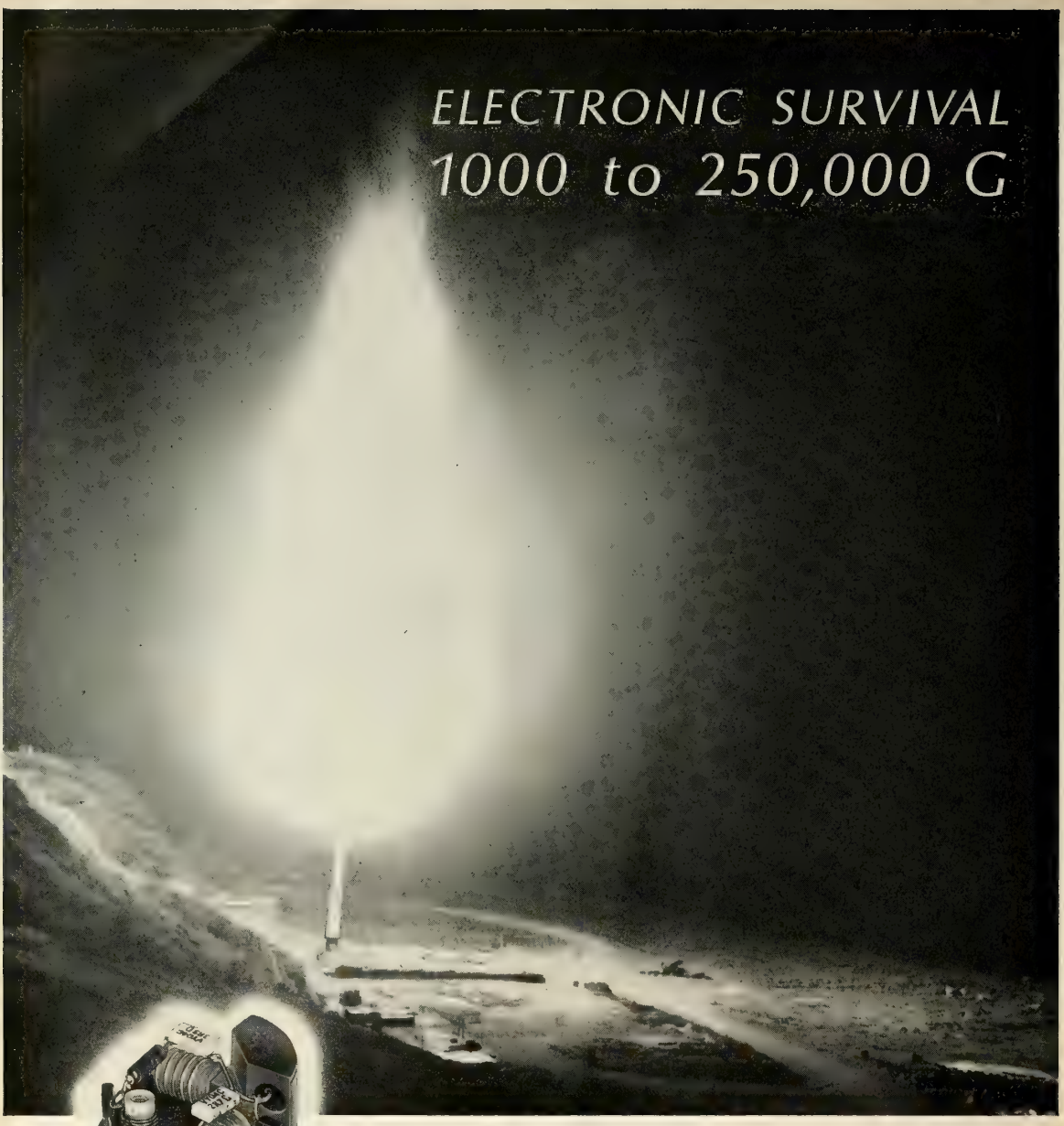

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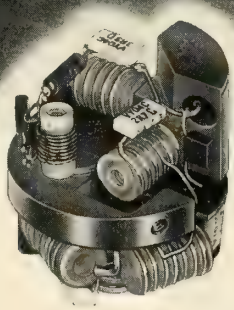

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Systems Division Concerned With Electronics Analysis and Integration

Two labs will research analysis and measurement, methods, engineering psychology and power processing; refined mission requirements model among goals

F. L. NIEMAN, acting chief of Systems Div. Power Conditioning and Distribution Lab.

MAJOR ATTENTION within ERC's Systems Div. will be focused on the analysis and integration of electronic systems in the context of their projected missions.

The division, which remains leaderless at this point, is made up of the Systems Laboratory (SL) and the Power Conditioning and Distribution Laboratory (PC&DL), an unlikely combination.

The SL, which embodies all of the stated goals of the division, is already involved in contractual activities, though a large portion of its work will not begin in earnest until the lab is in its permanent site. Budget for this lab in FY'66 is pegged at $500,000-600,000.

The PC&DL, the last lab to be built at the permanent site, does not yet have any on-going programs, but expects to initiate some work in FY'66. Budgets for this lab are not yet definitized, according to NASA.

Systems Laboratory

The SL's mission breaks down into five major research areas: systems analysis, systems measurement, methods research, engineering psychology, and flight test. Systems analysis and engineering psychology areas, pending installation of a wide range of test equipment in the permanent lab site, will represent most of the near-term work.

Acting lab director Ernest R. Steele points out that this lab, which will research many areas having broad center-wide interest, is one more directed toward engineering goals than necessarily advancing the equipment state of the art, as is the case with many other labs. Much of the work going on here will be support-type activity.

- **Mission requirements model**—A primary example of this type of effort will be the lab's attempt to develop, and continually up-date, a refined mission requirements model that would provide

the probable performance requirements of electronic systems needed for future NASA missions. This type of engineering function is viewed as the logical basis or first stage of what will be future research and engineering developments undertaken throughout the center.

The model is not intended for specific missions, but rather broad flight categories such as interplanetary flight or solar probes. The major expectation is that it will provide some indication of the relationship between mission success and an electronic system's parametric performance.

The SL has already started this program, using FY'65 funds to initiate a competitive award won by the AC Spark Plug Div. of General Motors Corp. for a study and mathematical model of interplanetary guidance requirements.

In FY'66, the lab is expected to initiate several other awards similar in nature to the AC Spark contract in areas of communications, control, instrumentation, and on-board computer requirements. There are other long-range plans for studies in areas such as deep-space rendezvous guidance and control.

● **Astronaut's 'Guide to Space'**—In addition to the mission profile, the lab's work in systems analysis will also include compilation of a so-called "Aerospace Environment Handbook," which will involve a major job of collecting data from numbers of existing sources and documents with an eye toward tailoring the volume specifically for NASA missions contemplated over the next 15 years.

The lab's role in system analysis will also be extended beyond the modeling of missions and broad electronic systems requirements into what will be called synthesis and feasibility studies of particular electronic systems.

For example, in the FY'66-68 time period, the lab is expected to undertake a systems synthesis task in the area of terminal landing guidance and control. This would be applicable to maneuverable spacecraft after the re-entry phase and under possibly adverse weather conditions in the atmosphere. Another such synthesis is proposed in the area of radar mapping of the oceans.

The lab's work in the systems measurement category will largely await the installation of test equipment at the permanent site. The intent, once it is in place, is to provide a professional test, evaluation, and measurement service to other labs, or to allow other labs to do the testing with the SL equipment. The lab will be set up to test both newly available commercial equipment of interest to NASA or other ERC experimental equipment.

The research into what ERC calls engineering psychology will be mainly concerned with expressing those performance characteristics of man that specify his behavior as a component of an electronic system. It is not a straightforward human factors type of research and will, according to scientists here, involve much more experimental research than does human factors engineering.

This type of research will seek to develop models, and from them, improved interfaces between man and the electronic system, in areas such as operator reliability, his performance under stress, his ability to serve as an information-transfer vehicle, and the effect that control system geometry has on operator performance.

● **Flight-test coordinator**—One of the SL's most important functions will be in the area of flight testing of ERC-developed components and systems. The lab will have the basic responsibility for coordinating flight-test requirements for the Center and for insuring that an experiment's engineering design is compatible with the vehicle aboard which it will be flown. It will also be responsible for keeping abreast of the various flight-test opportunities that may be of interest to Center experimenters. Responsibility for the scientific aspects of the experiments will remain with the originating laboratory.

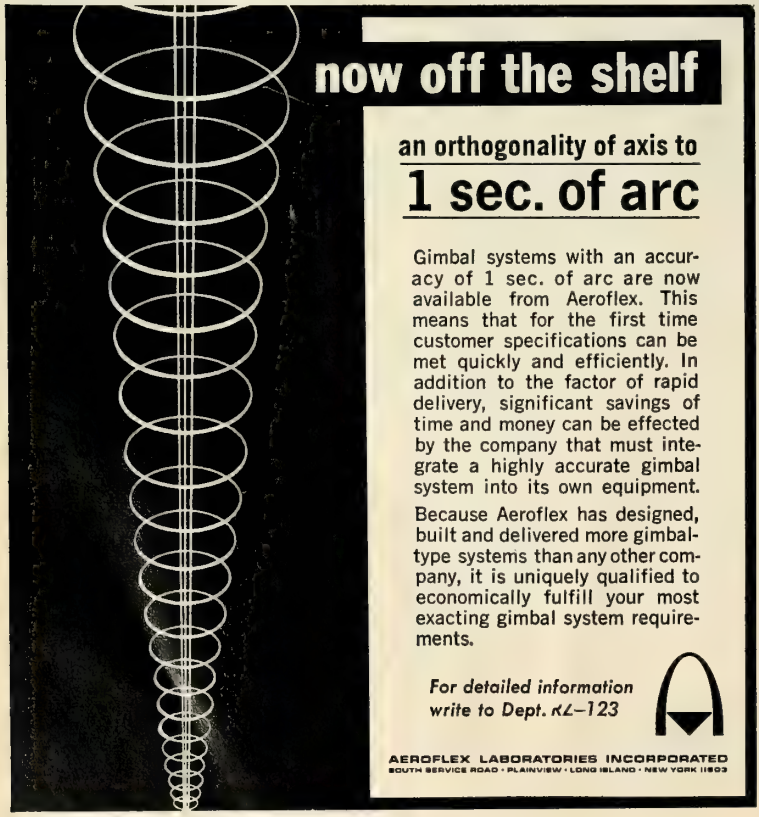
The first such flight test has already been proposed by the Computer Laboratory. It involves flying certain computer logic elements aboard one of NASA's *Applications Technology Satellites* to test degradation of the elements in the space environment. The project, for which no hardware has yet been built, still needs NASA Headquarters approval, and the earliest opportunity for fully defining the experiment package for the *ATS* will be in October.

Power Conditioning and Distribution Laboratory

The prime mission of this laboratory, still in the early stages of detailed planning, is to improve the operation of space power systems by taking a very close look at the electrical and electronic aspects of the systems rather than the energy sources or conversion schemes.

This area of power processing is an old one, says acting lab director Dr. Frederick L. Niemann, but it has only recently been recognized as a field in itself demanding attention to details other than just the conversion and source areas.

These latter portions have generally occupied most of the thinking done in the power source field. "There has been a tendency to just regard this as an off-the-shelf operation where one goes out and buys a converter without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too much regard for what it does to systems efficiency or how it affects those other major components upon which so much time and effort has been spent. Because there has been little attention paid to the processing involved in voltage changes or power level, for example," Niemann points out, "the lead time in developing current power processing systems has been short, with the requirements coming close on the heels of the decision regarding the source and conversion system."

● **Five areas of work**—The PC&DL work is classed in five broad areas: electrical and electronic components, circuits and systems, methods of battery charge control, systems standardization, and radio frequency interference studies.

Emphasis in the components area will be placed, at least initially, in development of improved switching elements, especially dc-to-ac devices. This element is currently regarded as a limiting factor in improved space power systems. The lab will make a survey of the switching field prior to making awards in this area.

Within the circuits and systems category, ERC is intent on improving the engineering design of power conditioning systems to take fuller advantage of the inherent reliabilities of individual components, both those now available and new ones that will be developed. There is a feeling that not enough attention has been paid to the engineering of these systems and that a situation exists where reliability is far below what should be achieved, given the performance of individual components.

There are two tasks tentatively set in this area. One involves development of improved low-voltage input converters that can operate over a wide range of load and power conditions. The other involves development of self-optimizing power systems utilizing energy storage principles that permit use in a widely varying load situation. This work could get started in FY'66 and might involve a sensor-actuated system, possibly using a variable frequency inversion scheme.

Another area of potential lab support in FY'66 is research into new ways to instantaneously determine a battery charge state and to continuously monitor that state. Ability to accomplish this would greatly increase efficiency with which batteries are used in space missions.

The lab's role in standardizing spacecraft power requirements and power system component and circuit specifications is still "just a gleam," according to lab officials. A similar case exists in the RFI area, where efforts eventually will be directed at reducing the amount of stray radiation introduced into spacecraft design by the power conditioning equipment. ■

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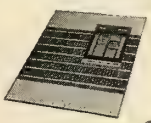

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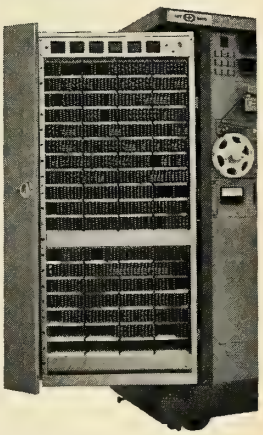

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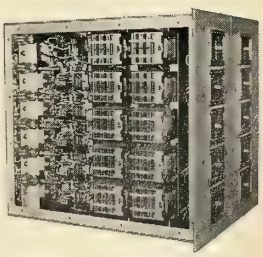

1000-TERMINATION MODULE used in control and switching consoles. Bar-relay (10 seen here) is heart of rapid block-testing technique.

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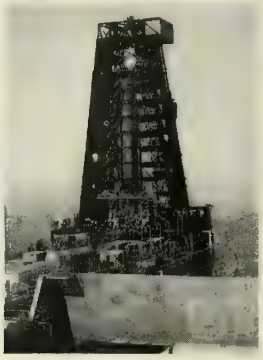

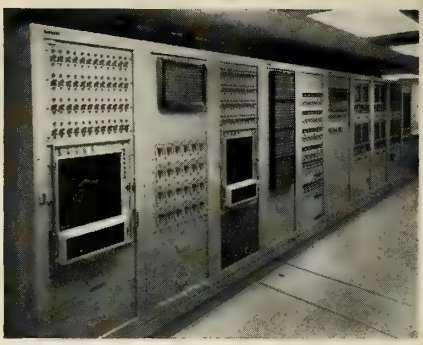

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Instrumentation and Data Processing

Long-term definitive jobs have been assigned to both Instrumentation Research Laboratory and Computer Research Laboratory; plans outlined

THE INSTRUMENTATION and Data Processing Division of ERC will by the 1970's provide many major technical guidelines to the NASA centers, for the two laboratories comprising the division are planning very fundamental approaches in each field.

Both have chosen goals of very long-term interest and selected tasks not generally being pressed in U.S. industry.

Whether the research is directed toward metrology or computation, a concerted effort will be made to significantly improve reliability, maintenance of performance and final accuracy. In each field there is extensive room to grow and a great need for improvements.

Instrumentation Research Laboratory

The tools of metrology will be fashioned, advanced and improved for aerospace use by ERC's Instrumentation Research Laboratory.

Under the direction of Dr. Gene Manella, acting chief, the laboratory will direct its efforts toward three principal research areas: astrophysical measurement, bio-electronic measurement and engineering instrumentation.

In general, the laboratory will strive to develop advanced measurement techniques as an overall capability. Its efforts will cover the range of research before instrument design and show feasibility. Manella stressed that it will not be heavily concerned with actual hardware development.

However, breadboards may be flight-tested at times to prove feasibility.

Manella includes three distinct fields of measurement within the laboratory's astrophysical research program:

—Planetary atmospheres: this encompasses sensor problems in aeronomy and meteorology and includes the detection and measurement of species of low concentration—approaches might include use of laser-beam or millimeter-wave technology.

—Solar physics measurement.

—Micrometeoroid diagnostics: this involves the problem of measuring particle diameters as small as one micron and velocities of 20-70 km/sec. (Because of the similarity of technical interests, the laboratory is expected to work closely with the Air Force's nearby Cambridge Research Laboratory in these three areas, as well as in other optical sensor research.)

In the laboratory's bio-electronics program, Manella disclosed, a major effort will be directed toward development of techniques for remotely monitoring physiological conditions.

A second long-term project will be development of a reliable, complete system approach to the analysis of bio-data.

A third problem area is that of developing accurate, reliable life-support instrumentation for use in a closed ecological system within spacecraft.

The improvement of more basic instrumentation falls into Manella's third research category—engineering. Here, the laboratory will attempt to improve methods for measuring basic physical variables.

In addition, optical instrumentation will be considered. Necessarily, much of the optical work will be in support of the Space Optics Laboratory at ERC.

- **Sensor research**—In its overall sensor research program, the laboratory will strive to generate a whole class of extremely versatile sensors around which high-reliability measurement systems can be designed when needed.

One such sensor will be for providing the absolute measurement of submillimeter power in the frequency range of 330-3,000 gc. Early attempts will be to produce an instrument that will detect a signal of 10^{-6} watts with a 1-sec. response time (by Fiscal Year 1966) and later detect a signal of 10 watts with a 1-ms response time (by FY '68).

Other major sensor developments to be made by the laboratory include very-low-noise IR detectors, selective ultraviolet and soft X-ray absolute detectors, physical analogs of biosensory transducers, and reliable, rugged vacuum gages capable of measuring from 10^{-14} to 10^{-15} torr.

Computer Research Laboratory

The Computer Research Laboratory will maintain an inclusive theoretical approach to advancing both hardware and software.

Its present plans encompass a very broad and ambitious program which breaks down into four distinct research areas: theoretical studies, spaceborne computers, flight operations, and man-computer interactions (also spaceborne).

In addition to its research function, the laboratory will help determine the extent and type of in-house computation and data-processing system needed by the Electronics Research Center and will be responsible for its operation.

- **Theoretical studies**—The most fundamental research performed by the laboratory will be in the area of advanced concepts, according to Dr. Burke, acting laboratory chief.

Research will include the study of the physics of materials. Studies may vary from components to people. Eventually, the field of bionics will be included with theoretical studies of electrochem-optical techniques as associated with computation and control.

Human intellectual processes will be investigated as a means for developing better electronic techniques. Also, in association with the Guidance and Control Laboratory, the application of fluidic techniques for systems will be studied.

- **Spaceborne computers**—The laboratory will look into the use of computers for performing analysis and synthesis procedures to prove new spaceborne computer designs before fabrication. Burke said it is hoped that such procedures will significantly improve both performance and reliability of flight hardware.

Other design studies will look into

system operational degradation and seek to increase computer subsystem radiation resistance. The laboratory also will endeavor to learn how to design for full use of threshold elements.

Technological breakthroughs will be sought for spaceborne computers in data capacity, operating speed and instruction repertoire.

From a system approach, better input/output techniques will be investigated to increase flexibility and effectiveness in the diverse uses of flight hardware.

● **Flight operations**—This area of research will be concerned with the use of the computer from assembly to prelaunch to in-flight processing and data transmission.

The laboratory will develop techniques and devices to assure system quality throughout assembly and devise checkout routines to maximize the probability of mission success.

Research will be directed toward overall improvement of flight data-processing systems including signal conditioning, formatting, data compression and other adaptive techniques. In short, researchers will study methods for obtaining more effective usage of in-flight systems.

● **Man/computer roles**—The interface and interaction between man and computer will be studied to improve overall performance. Problem formulation, input/output, solution will be intensely pursued to improve man/machine communication.

A parallel effort will be applied to development of advanced computational techniques for manned spaceflight uses.

● **In-house computation**—The laboratory is now studying the various approaches that might be taken to provide the center with data-processing adequate for all needs and capable of growth.

Two approaches are now being considered: one is based on use of a number of small machines for ready access and a conventional ADP center for servicing more complex or time-consuming tasks; the other would make use of a very-high-speed, multiple-access computer tied to each user through communications links and employing time-sharing and parallel processing.

● **Current program**—Although the laboratory's facility is not scheduled to be completed until late 1967, it already has a small research effort in progress.

Proposals are now being reviewed for three separate research contracts:

—A study of techniques and devices for achieving long-term, failure-free computer operation in space. This should provide a basis for future research for advancing the state-of-the-art in spaceborne computer reliability, Burke declared.

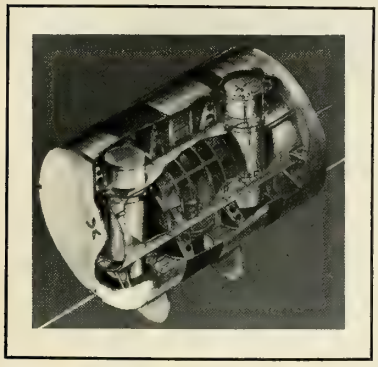
—A study to determine methods for reprogramming on long space missions. Eventual development of practical associative memories suited for such missions is inherent in the effort, which also will evaluate near-future devices relative to application in parallel-search memories.

—Analysis of the feasibility of using pattern recognition techniques for both extracting significant data from pictoral data and for reducing the total amount of data prior to transmission.

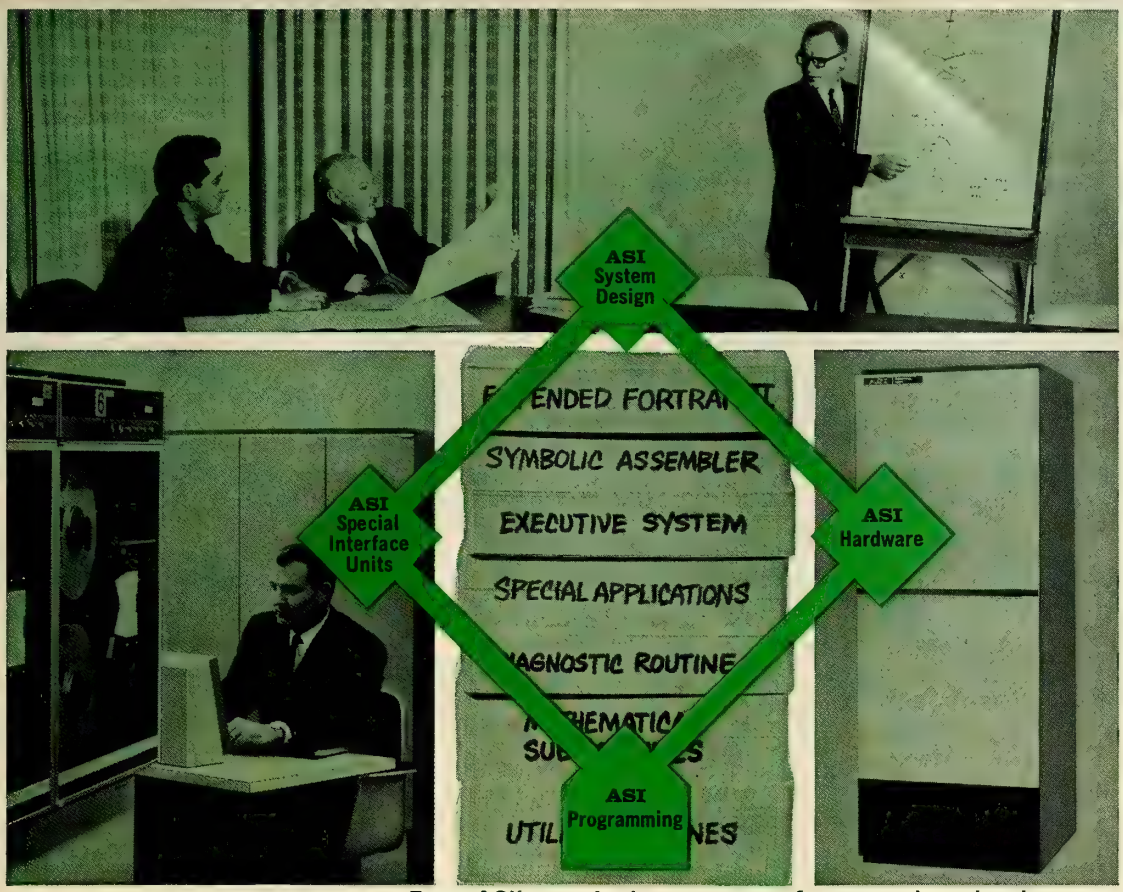
In FY '66, Burke disclosed, the laboratory will perform more device work (memories, mainly) for long-term space missions.

It will investigate fluidic techniques for non-moving-part, fluid-powered computers.

Input/output devices also will be studied. ■



LEFT: Proposed Optical Technology Satellite being studied by Marshall Space Flight Center may be used for ERC flight experiments. BELOW: Expandable high-gain spacecraft antenna fabricated at Jet Propulsion Laboratory. ERC effort will be directed at increasing gain of such antennas, and at increasing power and efficiency of spaceborne microwave devices.



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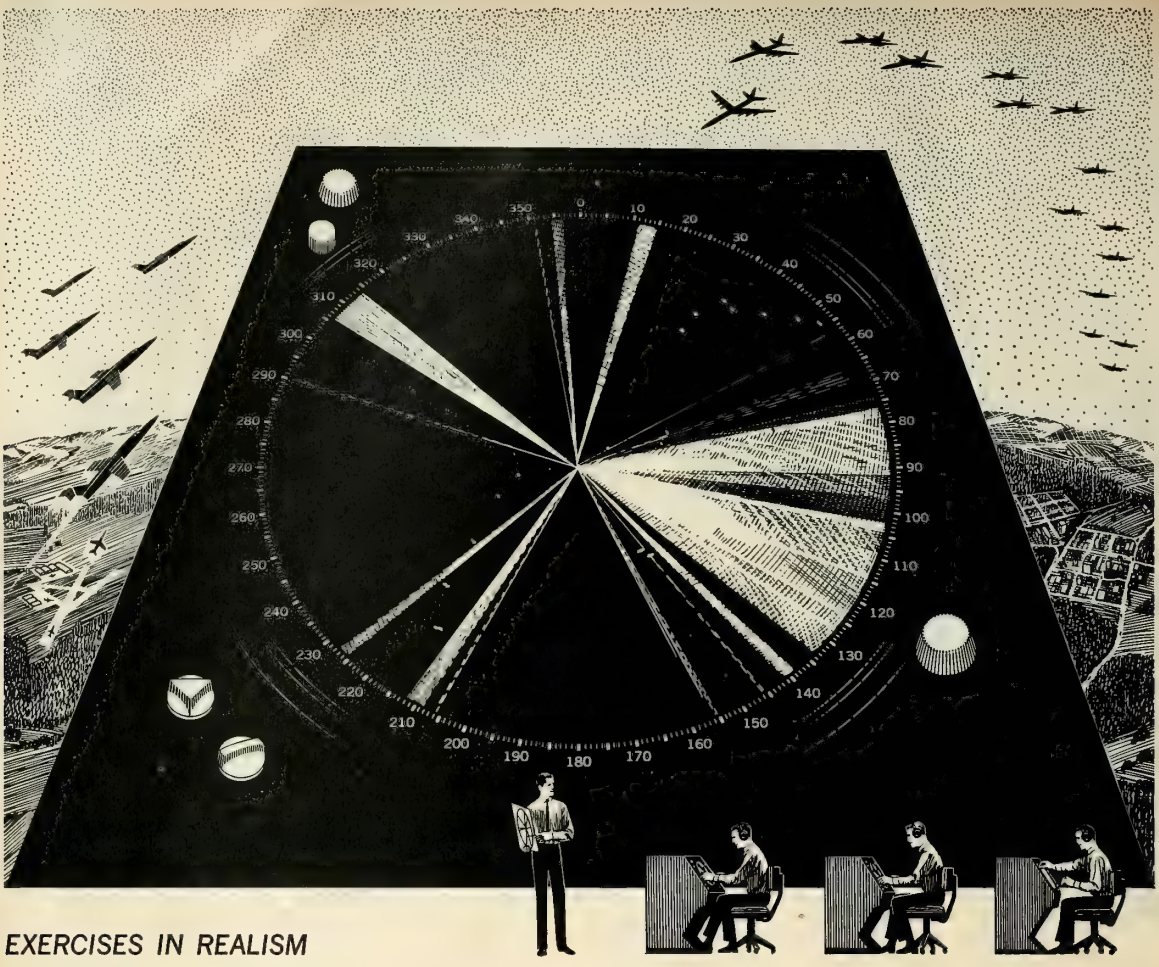

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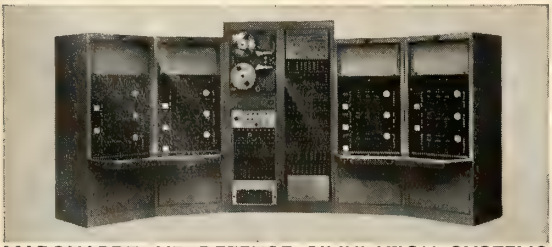

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Electromagnetic Research Effort Aimed at Deep-Space Communications

Microwave, optical techniques to be investigated by two labs to improve long-range transmission; ten-year goals established

TWO LABORATORIES comprise the working elements of ERC'S Electromagnetic Research Division: The Microwave Radiation Laboratory and the Space Optics Laboratory. They will seek increased knowledge of the entire electromagnetic spectrum, including general theory, active and passive systems and techniques, both manned and unmanned space mission support, says Dr. Lester Van Atta, division director.

A major assignment of both laboratories will be the improvement of long-range space communications. They will seek to learn under what conditions either microwave or optical techniques might provide the best communications for a given task.

The microwave laboratory will strive for a payoff in five years, providing a transmission rate of up to 10^6 bits/sec.; the optical group will set a 10-year goal of 10^8 bits/sec., Van Atta disclosed.

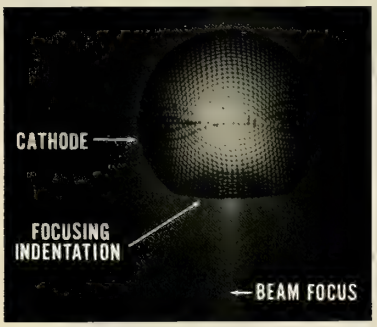
Half the division's effort will be maintained in-house, the other through outside contracts. Large special-purpose side equipment at other centers will be used when possible, rather than attempting to duplicate at ERC, Van Atta stressed.

Long-range needs in the field of electromagnetics have been sought from all the NASA centers by Van Atta and from these he and his associates have devedoped their initial 5-10-yr. research goals. In general, he says, his group will extend its research through the proof-of-feasibility phase, building only that hardware necessary to support its research.

Van Atta says that once his division is established as a working entity, the general approach to research projects will be handled as follows:

—Crucial research areas will probably be handled internally.

—A leading expert in the field of the specific research under consideration will be engaged as a consultant.



PLASMA penetration device being investigated under an ERC-initiated study to try to solve the re-entry blackout problem.

—At least one outstanding research team will be contracted.

—Later, additional contracts may be let to industry groups alone for development of special-purpose techniques or equipment.

Microwave Radiation Laboratory

Four major research areas will be conducted by the Microwave Radiation Laboratory, with primary emphasis on microwave- or millimeter-wave techniques: deep-space communications, communication through plasmas, clear-air turbulence, and aerospace science support.

As indicated earlier, the microwave Laboratory has drawn the task of providing an early, but significant, improvement in deep-space data transmission rate. The need for a 10^6 bit/sec. capability over interplanetary distances by 1970 seems assured and based on today's technology, it appears that the best approach to attaining this goal at that time is through use of microwave techniques.

There is an urgent need to provide a means for reliable communications at all times to and from space vehicles and hypersonic aircraft. Both, at times, generate a plasma sheath about them during very-high-speed flight in the atmosphere.

Both microwave- and millimeter-wave techniques will be investigated to find a reliable means to detect and diagnose the occurrence of clear-air turbulence by supersonic aircraft. There is not even a clear understanding of the problem so far, much less any solution for it.

The final area of research interest, aerospace support, is a catch-all for general research to be conducted by the lab to advance microwave technology on a broad front. Particular emphasis will be in the fields of radio astronomy, meteorology and aeronomy.

• **Long-range communications**—To achieve better space communications, several major study areas have been selected by the lab:

—System trade-off studies;

—Vehicle RF power generation;

—Communications bandwidth utilization;

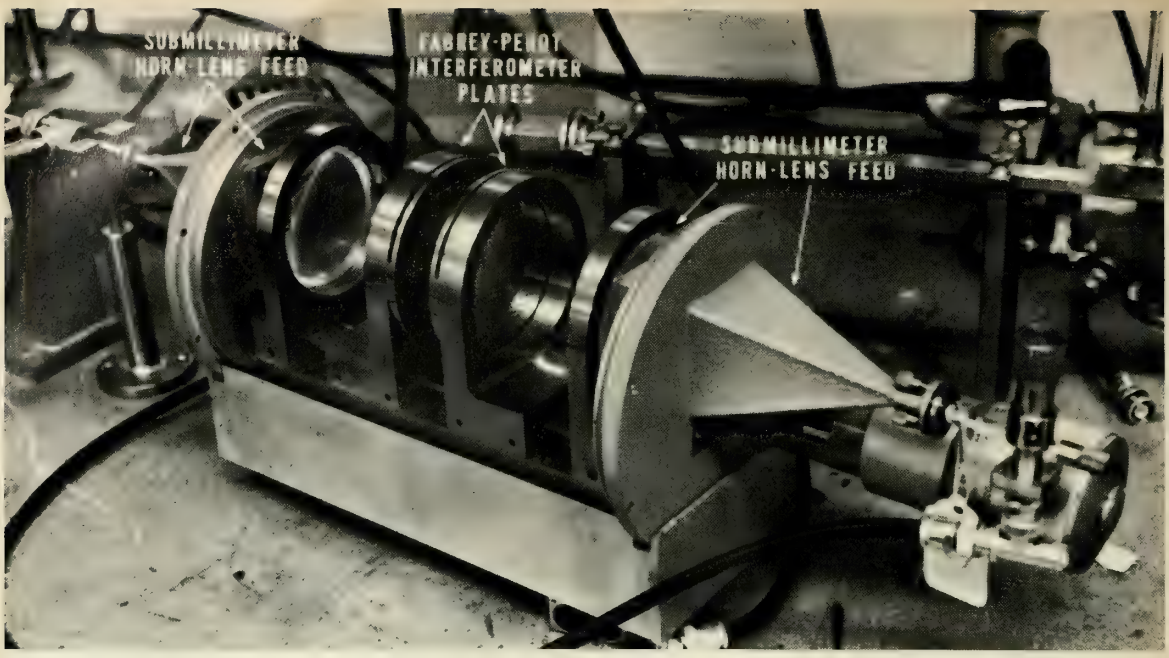
—Experimental systems testing (including flight testing).

The contributions to overall system performance and effectiveness of many major system elements will be investigated in the trade-off studies. Competitive frequencies will be studied and an optimum system will ultimately be selected for development.

A key mission in this effort is a Mars landing. Such a mission, NASA officials have indicated, will require voice, teleprinter, telemetry and television transmissions.

Associated trade-offs also will include analyzing the advantages of various coding and feedback technique combinations over the two-way radio link.

Existing and new RF power-generation techniques suitable for space vehicle use will be studied with a view toward defining maximum power output and payload weight limitations.



FABRY-PEROT interferometer being used to study sub-millimeter frequencies in an ERC-funded industry program.

Collective interactions effects in solid semiconductors, producing microwave oscillations and direct dc-to-microwave conversion, will be studied. Through a better understanding of Gunn oscillation behavior in materials, methods for obtaining higher frequencies with greater efficiency and high-power output from oscillating solid diodes may be practicable. (Reportedly, such oscillations already have been observed at 29 gc. At 1 gc, peak outputs of 5 watts have been obtained.)

Unfurlable and inflatable dishes or arrays for spacecraft application will be researched to achieve maximum gain with minimum weight penalty. Honeycomb and elastic materials will be considered.

A very-large-aperture, electronically steered ground antenna will be studied and designed by the lab. Although Dr. Van Atta did not disclose the antenna size, he did indicate that the design effort would include a scale model sufficiently detailed to show fabrication feasibility and working integrity.

Adaptive techniques, data compression, and on-board processing will be studied to find ways to improve bandwidth utilization in deep-space communications links.

The results of all these studies will lead to development of crucial prototype hardware, which the Lab will strive to flight-test piggyback aboard various NASA space vehicles. Experimental flight tests are planned beginning in 1970.

● **Plasma studies**—Fundamental lanes governing density, distributions, and persistence of plasmas generated during spacecraft launch and re-entry and by hypersonic aircraft will be the goal of continuous research at the lab.

Again, a five-year goal has been set for the determination of optimum frequencies that will penetrate plasmas reliably for the various flight missions. Hardware will be developed to support the theoretical effort.

● **Aeronautical support**—Clear air turbulence (CAT) occurs generally above 20,000 ft. altitude and commonly at about 35,000 ft. The effect on jet aircraft can be disastrous, thus an intensive national effort is being made to better understand and solve the problem.

Both microwave- and millimeter-wave techniques will be investigated for use in detecting and diagnosing CAT.

The lab ultimately will develop and fly an experimental CAT warning system. The time goal is three to five years from now.

● **Aerospace support**—In the more general area of aerospace support, the lab will direct its efforts into the special fields of radio astronomy, meteorology and aeronomy.

Propagation studies at millimeter and sub-millimeter will be made.

Other research will be directed to:

—Solid-state circuit development;

—Receiver heterodyning components;

—Material studies (quantum effects, piezo-electric effects, etc.);

—Millimeter and sub-millimeter measurement techniques.

In addition to its broad research program, the laboratory will collect all available data reflecting the state of the art of the microwave portion of the EM spectrum from 10 cm. to 0.1 mm.

Space Optics Laboratory

More than 40% of the Space Optics Laboratory effort during the next five to ten years will be committed to laser research—particularly in connection with long-range space communications.

Since the lab is concerned with all aspects of the optical portion of the electromagnetic spectrum, its mission includes three other general study areas: high-resolution photography, the detection and diagnosis of clear air turbulence, and aerospace science support in optics.

The laboratory will investigate the entire region of the EM spectrum from 100 Angstroms to one millimeter wavelength, and this includes both active and passive techniques.

● **Space communications**—According to Dr. Max Nagel, laboratory director, ERC will seek through research means to increase communications rates over great distances in space with improved efficiency. The latter includes better utilization of vehicle payload weight.

Task areas will include:

—Emphasis on laser communications;

—Material studies (seeking new frequencies or higher reliability);

—System susceptibility to space radiation;

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Inherent in much of the laser studies, which will be designed to provide improvements in space-to-space communications during the post-*Apollo* period, is the fact that by 1975 a capability for transmitting 10^8 bits/sec. must be available. An alternative to this need is the capability to communicate with reasonable performance and high reliability over a distance of three astronomical units.

Critical study areas, according to Dr. Nagel, include: optical communications effectiveness, generation and amplification of coherent optical radiation, modulation of optical radiation, transmission techniques and detection of optical radiation.

● **Mapping and imagery**—The space Optics Laboratory will study optical techniques for obtaining and collecting on Earth high-resolution photography that has been transmitted over great distances in space.

Other research will be directed toward development of high-resolution film, together with vidicon techniques and data processing of video facsimile data.

Components also will be developed for use in high-resolution photography and for use in the return of information with a minimum demand on the communication link.

Three-dimensional displays will be studied for use in investigating future or potential landing sites in space. Techniques will be developed, including real-time transmissions, for using cooperative spacecraft.

Lenseless photography (holography, using a laser for coherence) also will be considered for three-dimensional displays.

High-resolution infrared and ultraviolet image conversions into the visible region will be investigated. Also, the conversion of optical images into a form suitable for on-board data processing will be studied.

Both conversion devices and prototype systems will be developed in these areas for space vehicle use.

An important area of study will be that of video data processing, including TV data compression and other adaptive techniques. The need is based on the increasing requirement to reduce bandwidth demand in long-range communications and to minimize on-board data storage requirements.

● **CAT studies**—Clear air turbulence continues to be a serious problem in high-speed air transportation. Using laser and other optical techniques, the

lab will attempt to find methods for detecting and understanding the phenomena.

Hardware will be developed under the program to permit suitable aircraft response. Solutions must be found to minimize CAT encounters, particularly by supersonic aircraft. All established theory on the formation of turbulence and the correlation of theory with the measured spatial and seasonal occurrences of disturbances are necessary prerequisites of prediction and avoidance, said Dr. Nagel.

Optical characteristics of field of view which might be used for detection must be studied further.

The entire CAT problem and its solution will represent a very large portion of the laboratory's passive optical study effort. Active techniques also will be employed.

Temperature mapping and IR shadow photography (passive) and observation of laser beam backscatter (active) are typical approaches to be investigated.

Prototype devices will be built and tested under the program, according to ERC officials.

Other optical areas to be studied include ozone detection and star-image dancing introduced by turbulence.

● **Support effort**—The development of optical techniques common to many areas of aerospace technology will also be undertaken by the lab. These problems generally will be studied separately from the applications.

Typical areas of study will include:

—Effect of optical transmissions through various mediums;

—Omnidirectional optical communication;

—Non-linear optical effects;

—Low-temperature effects (for telescope technology) and also zero-g and radiation effects;

—Optical noise problems;

—Large-telescope performance control;

—Light-source tracking;

—Optical communication through plasmas.

Through the study of selected problem areas, the lab will attempt to provide optical techniques and instrumentation needed to advance aerospace science and technology, says Dr. Nagel.

New optical techniques and devices will be developed related to aerospace applications. Principles and initial plans will be developed for Moonbase research to support scientific and technological studies.

The technology of large-aperture, low-noise optical receiving systems will be investigated, along with related techniques.

Measurement techniques and calibration procedures will be developed for optical experimentation and, hopefully, will be improved, Nagel stresses. ■

It takes a demonstration to show everything this oscilloscope can do. For, with a Type 547 and 1A1 unit, you can display both time bases separately or alternately. This, alone, speeds up and simplifies a wide range of oscilloscope applications.

Also, you can operate one time base as a delay generator. This capability allows an alternate presentation of a waveform brightened over a selected portion, and the selected portion expanded to fill the full 6-cm by 10-cm display area.

And, for increased signal-handling versatility, the Type 547 accepts any of the many established up-to-30 Mc passband "letter-series" plug-ins, or any one of the new spectrum analyzer plug-ins—giving wide choice of plug-ins for particular applications.

Call your Tektronix Field Engineer for a demonstration—and see for yourself how this new oscilloscope can update your laboratory.

Type 547 Oscilloscope. $1875
Type 1A1 Dual-Trace Plug-In Unit . . . . . $ 600

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Our new static frequency converter's power-to-weight ratio is several times better than any other static converter.

When you compare it to a typical motor generator set or rotary converter, the difference is phenomenal.

This new converter, now in production, changes 400-cycle power to regulated 60-cycle power. Converters also can be built to take 50, 60, or 400-cycle in *or* out. Or they can be designed to split the power so that 400 and 60-cycle outputs are available simultaneously.

Our static converters work well with standard piston engine generator sets – but when combined with Garrett-AiResearch 400-cycle gas turbine generator sets, they are the lightest weight and most compact dual frequency power sources available anywhere.

Garrett's secret is solid state circuitry built around silicon controlled rectifiers in an entirely new way. The design incorporates a highly efficient commutation system that keeps power loss to a minimum. Total unit efficiency is better than 90 per cent.

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Electronic components are mounted on unique cold plates for cooling, so that sensitive parts are never exposed to outside air contamination.

Need higher power? We also have systems up to one megawatt.

For more details on Garrett's solid state converter capability, write to: Clarence Frere, Manager, Electrical and Electromechanical Systems Sales, AiResearch Manufacturing Division, Torrance Facility, 2525 W. 190th Street, Torrance, California.

PERFORMANCE SPECIFICATIONS

INPUT:	400 cps ±5% 120/208 volts ±5%
OUTPUT:	60 cps ±0.5% 120 volts ±1% single phase sine wave, less than 5% total distortion. 15 kva continuous 22 kva overload

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Space Guidance Work To Be Isolated

Four-branch lab will have equipment cost of $1.6 million in FY '66, total construction price tag of $4.9 million through three years

ONE OF THE FIRST labs to be constructed and functioning will be the Space Guidance Laboratory, part of the Guidance and Control Division. The lab will have four branches—Inertial Reference, Guidance Trajectory, Electromagnetic Guidance, and Navigation Techniques.

Equipping the lab will run to an estimated cost of $1,651,889 in Fiscal Year 1966 funds. This will cover some 350 items. Total construction cost is pegged at $4.9 million, with $3.9 million coming out of FY '66 funds. When fully operational, the lab will employ 190 people and the last construction increment will be spent in FY '68.

The lab will be at an isolated site since the experiments envisioned would suffer if too close to sources of radio frequency and seismic noises. The main lab will have 35,000 sq. ft. of floor space, and an auxiliary site will add another 14,400 sq. ft.

The lab will provide management, facilities, planning and programming for all aspects of space guidance. Requirements for guidance-oriented research facilities and research flight experiments will be originated by the lab.

● **Inertial Reference branch**—Inertial position, velocity and acceleration sensors based on Newtonian Mechanics will be investigated by the Inertial Reference branch. Research into acceleration devices using proof masses from subatomic size upwards will also be initiated.

Work in intertial reference system platforms and gyroscopes will be part of the branch's responsibility, as will maintaining and developing knowledge of various gyro techniques such as nuclear magnetic resonance, cryogenic, and laser gyros. A research program in frictionless suspension systems using ultrasonic, nuclear, electrostatic and cryogenic principles will be initiated.

The branch will operate a complete inertial research facility and design research experiments to prove the physical principles of proposed new inertial reference systems.

Novel computer technology will be applied to the computation requirements of inertial sensing systems, and new computer technology simplifying inertial guidance system equipment will be introduced.

● **Guidance Trajectory branch**—Programs involving trajectory analysis conducted against a background of current research to identify mission limitations imposed by guidance technology will be the job of the Guidance Trajectory branch. This unit will study all phases of space guidance requirements and objectives, including launch, abort, rendezvous, midcourse, planetary landings and take-off, and re-entry.

The theory of low- and high-thrust trajectories will be studied as well as two- and three-body problems, transfer orbits and computer implementation of trajectory calculations in order to generate nominal flight paths for typical space missions.

● **Electromagnetic Guidance branch**—The Electromagnetic Guidance branch will provide technical administration, planning and programming in conducting broad research programs in active, semi-active and passive techniques.

This branch will originate and implement requirements for electromagnetic spectrum occupancy and for electromagnetic guidance research facilities and flight. It likewise will direct radar research programs and investigate altimetry, detection, tracking and navigation, spaceborne surveillance, Earth-based radar and beacons or transponders.

It will also initiate technical approaches and conduct research programs to advance the state of the art in radio command guidance, remote altitude sensing, TV guidance, optical guidance and related adaptations.

● **Navigation Techniques branch**—New navigation concepts for space flight such as electromagnetic instruments will be the concern of the Navigation Techniques branch. Potential devices using new principles will be researched.

Time standards required for space flight navigation will be examined and the branch will exploit advanced technology in mechanical, electrical and electronic clocks applicable to navigation fixes.

There will be theoretical studies into electromechanical, piezo-electric and atomic time standards, methods of transmitting time signals and techniques of synchronizing remotely operating navigation instruments. ■

Representative Equipment Procurement

The type of in-house and contracted research handled by the Space Guidance Lab is indicated by the sample listing of equipment to be purchased. The compilation is not complete and is intended only to implement the stated research and development purposes of the lab and its branches.

Optical master dividing head
Air-bearing torque tester
Photoelectric autocollimator
Vacuum system
Precision centrifuge
Visual autocollimator
Directional theodolite
Twelve-in. precision magnet
Exotic test room
Photoelectric autocollimator
Celestial projector
Photometric calibration set
Model A ABBE refractometer
Medium computer
Analog computer
Vacuum lab facility
Toroidal winder
Phase comparator
Optical comparator

Systems Facility Has Broad Duties

Branches will administer system analyses and simulate guidance, control, tracking, communications and instrumentation activities

THE SYSTEMS LABORATORY, part of the Systems Division, is one of the larger facilities at the Center. It includes four branches—Guidance and Control Systems, Communications and Instrumentation Systems, Machine Simulation, and Engineering Psychology.

Cost of completely equipping the lab is estimated to be $2,293,762, covering some 342 pieces of apparatus. Of this, $1,005,667 will be spent in Fiscal Year 1967 and the remainder in FY '69.

Construction funds programmed in present plans call for a total of $4.5 million, with $2.5 million originally scheduled for FY '66 and the rest in FY '68. At full strength, the lab will house 170 scientists and technicians. It will have some 44,000 sq. ft. of floor space at the main ERC site and another 7,200 sq. ft. at the remote site for certain work requiring isolation.

Systems Lab will plan and administer a comprehensive program in system analysis and simulation of guidance, control, tracking, communication and instrumentation functions involved in spacecraft and space exploration. Coordination of analog and digital computer facilities in simulation studies will be a prime function.

- **G & C**—The Guidance and Control Systems Branch will perform theoretical and analytical investigations into concepts and problem areas in spacecraft guidance, navigation and control systems. It also will develop optimum systems configurations for general and specific missions.

Systems will be simulated or synthesized to prove theoretical findings and to establish functional descriptions and interfaces.

Physical limitations on optimum system performance will be specified, and areas for advanced research intended to enhance or improve system capability to meet optimum performance requirements will be identified.

- **CIS**—The Communications and Instrument Systems Branch will plan and direct systems analysis and simulations of communications, tracking and instrumentation systems.

Advanced missions will be studied to determine their optimum communications and tracking systems configurations. Other functions are similar to those of the Guidance and Control Systems Branch—but oriented to communications and instrumentation.

- **MS**—The Machine Simulation Branch will develop digital and analog computers as tools for systems analysis and simulation and investigate new programming languages and techniques for improving the utility of computers as simulation tools.

This branch will advise computer users on avoiding program limitations, optimizing computer operating times and problem formulation processes.

- **EP**—Man-machine relationships and the integration of man into the electronic environment in space will be the prime responsibility of the Engineering Psychology Branch, which will provide engineering support for system analysis and simulation of electronic systems, including man as a systems element.

The branch's studies will assist in research on equipment augmenting human response functions and measure the variation of man's performance under extreme environmental conditions.

Optimum display and operator control system characteristics for general and specific missions will be determined in terms of environmental or physical constraints. Methods must be developed for displaying functions such as position, fuel, and equipment status; also needed are displays and controls for optimum transfer of information and efficient operator performance.

In addition, the branch will perform theoretical and analytical investigations of concepts and problems peculiar to display and control systems. ■

Representative Equipment Procurement

The brief listing below covers equipment characteristic of the Systems Lab. All common items, such as cameras, recorders, and measuring devices, have been omitted. The list is by no means complete, but will serve to indicate the depth and type of research to be pursued. As to individual items, the listing is not firm—minor changes can be made up until completion of the facility.

Voltage-controlled oscillator
Attitude simulator
Jet attitude vacuum chamber
Data acquisition system
Medium computer satellite
Hybrid computer
High-speed data collection
On-line correlation computer
Average-transients computer
Miniature telemetry transmitter
Telemetry receiver
Cockpit control panels
Closed-circuit color TV system
TV camera remote control carriage
Electronic signal simulator
Sonic analysis system
Cryoflux test facility
High-temperature chamber
Vacuum system
Residual gas analyzer
Force shaker

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EVERY TIME I HEAR ABOUT A COST-EFFECTIVE TACTICAL MISSILE SYSTEM IT'S THE SAME —PROMISES, PROMISES, PROMISES

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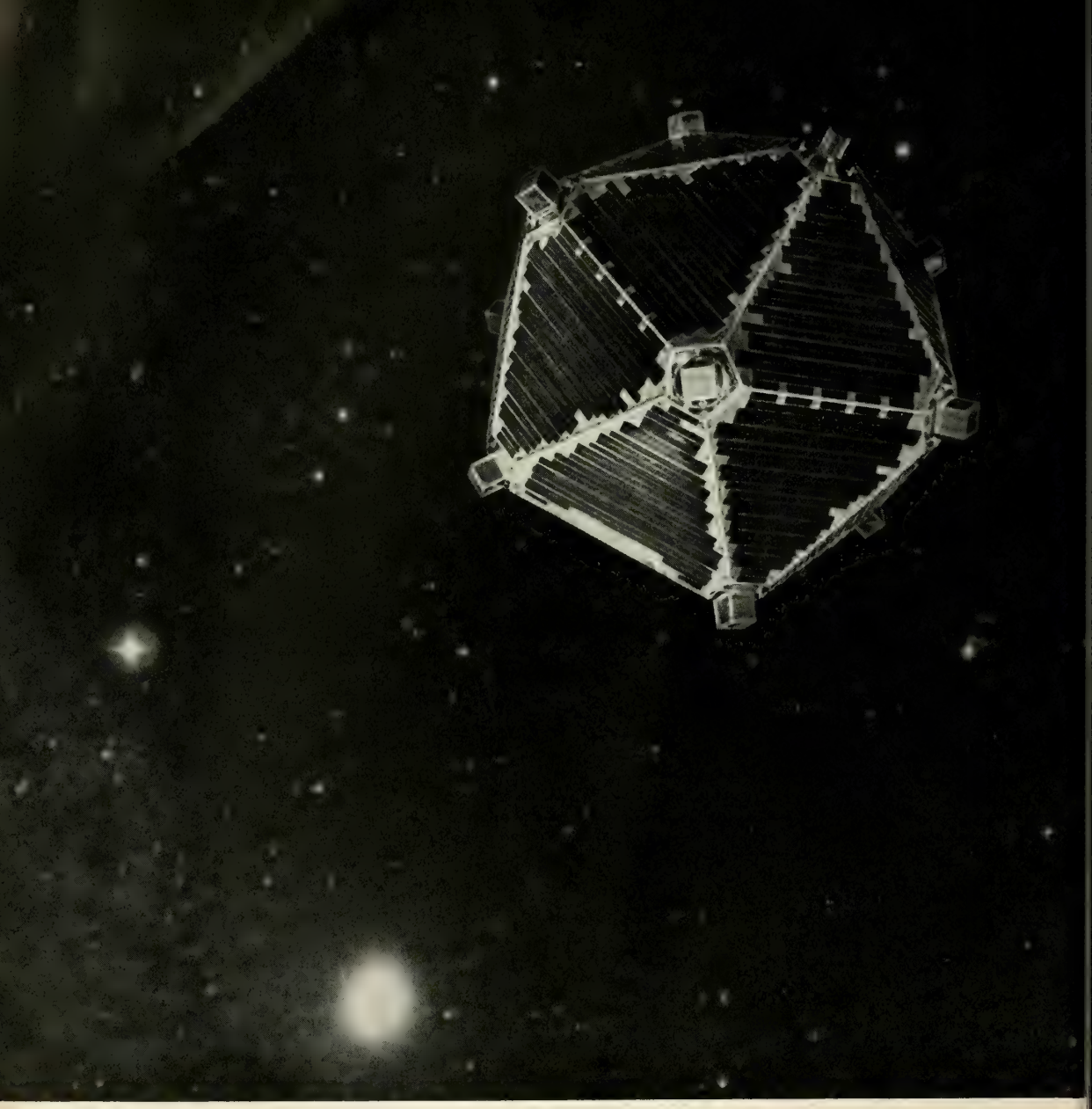

18 months ago they gave it 6 months to live.

When the first Vela nuclear detection satellite* was launched, its lifespan was estimated at six months. That was in October, 1963. Now, fifteen months later, it is still operating perfectly, monitoring radiation levels in outer space.

Sandia Corporation developed the miniature data-handling computer for this sentry in the sky. To meet the rugged requirements of blast-off and space environment, they designed in the most reliable components available, including more than 1,000 transistors and 3,000 diodes from Fairchild.

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*Vela is an ARPA-AEC sponsored project of the Air Force, Space Technology Laboratories, Sandia Corporation and the Los Alamos Scientific Laboratory.

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Computer Lab To Serve Entire Center

Outlay for equipment will exceed $873,000; three branches devoted to central computation, computer research and flight readiness

THE COMPUTER LABORATORY, part of the Instrumentation and Data Processing Div. (I & DPD) of ERC, will provide general applied mathematical and computing services for the entire center.

Some 570 pieces of equipment are currently programmed for this lab with purchase costs estimated to reach $873,770—about $306,137 to be spent in FY '67 and the remainder in FY '68.

Broken into three branches—central computation, computer research and flight readiness—the lab's primary mission is to conduct the basic and applied research necessary to meet computer and data-processing requirements of future NASA missions.

- **Computation branch**—The central computation branch will provide mathematical, programming and general data-processing services—including record keeping, fiscal and general management—for all units of ERC.

The branch will also provide special techniques, mathematical procedures, computer programs planning, and supervision of telemetry and ground test data-reduction calculations.

By working with the staffs of the other branches within the Computer Lab, the central computation branch will generate requirements for special interface equipment between sensors and computing equipment.

Input/output equipment and procedures for primary computing activities at the center—including graph and text reading, graph plotting and hard copy-generation devices and programs—will be provided by the branch.

The branch will also perform digital and hybrid programming for other branches of the Computer Lab and other labs in the center as required. The responsibility for maintenance of central computer library disc, tape and card files rests with this branch.

The branch will evaluate software requirements and assist in the development of programming systems of greater power and usefulness.

The computer research branch researches the areas necessary to compare existing or proposed advanced aerospace computer systems and supports the other divisions at the center in hybrid simulation systems and display research.

Novel or improved amplifiers, counters, multipliers, logical devices and other special requirements in analog, digital differential analyzer and related systems will be investigated by this branch.

Research in advanced card, paper and magnetic tape, disc or other comparable input/output handling systems will be conducted as will studies into graph and text reading, graph plotting, oscilloscope display and hard copy generating input/output devices.

- **Flight readiness branch**—The flight readiness branch conducts and manages research programs furthering the state of the art in checkout and countdown of vehicles from inception through assembly, pre-launch and post-launch.

A total of $4 million is programmed for the construction of the Computer Laboratory with $2.5 million earmarked for FY '66 and the rest in FY '68. All construction and equipment expenditures are pegged to acquiring land title and annual Congressional appropriations actions.

The Computer Laboratory will share a building with the Microwave Radiation, Instrument Research and the Control and Information Labs in the ERC urban plan. The Computer Lab is scheduled to have about 43,000 sq. ft. of floor space in the building.

In-house research programs will commence as the facilities become available and are equipped. Until this is achieved, the Computer Lab operation will be primarily concerned with monitoring outside contracts.

The Computer Research Lab build-up in personnel is based on the early recruitment of a moderate-sized staff.

This operation should have some 160 individuals by FY '69. ■

Representative Equipment Procurement

The following selected list of equipment to be purchased for the Computer Lab is indicative of the support, in-house and outside research work handled by the facility and its branches. The list is not complete, since much of the more common equipment such as cameras and recorders have been omitted. The individual items may change before the lab is completely operational, but these changes are expected to be minor with resepect to overall procurement.

Phase comparator
Audio signal generator
Low-frequency function generator
Fast pulse generator
Pulse generator
Signal generator
Incremental inductance bridge
Electronic dc-50mc counter
X-Y recorder
Digital recorder
Megohmmeter insulation tester
Desk computer
Centrifugal blowers
Data acquisition system
Shaker & power supply vibration test system
Temperature & humidity chamber
Vacuum bridge
Phase comparator
Oscilloscope recording camera
Pulse calibrator
AC/DC voltage calibrator
Square wave generator
Multi-purpose generator
Delay width generator
Sweep generator
Thermocouple
Spectrometer
Desk computer
Precision optical bench assembly
Infrared black body
Infrared thermistor detector
5-in.-dia. collimator
D-4 sensitometer
Stroboscope system
Laser head
Ruby laser rod
Gas laser system
Photo-electric autocollimator
Gas chromatograph
Viscosimeter
Annealing furnace
Quench tank
Controlled-atmosphere furnace

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Instrumentation Research

Lab will seek new approaches to measurements spanning range from astrophysics to biomedicine; will require advanced simulation chambers

The Instrumentation Research Laboratory will be responsible for improving or finding novel new approaches to the field of measurement. Its scope extends from astrophysical measurement (from the Earth's atmosphere to solar research) to biomedical instrumentation and into more conventional engineering measurement devices.

First equipment procurements, scheduled for FY '67, are expected to total $1,913,512 for 694 items. An additional $669,253 will be required for 381 items in FY '69.

Total expenditures will be $2,582,766 to initially equip the laboratory.

Construction costs are expected to total $3.5 million in FY '67 and $2 million in FY '69.

The total laboratory force will reach a planned 130 by 1970 and level off.

● **Simulators needed**—Several advanced simulators will be required by the laboratory.

One is an upper atmosphere (100-150 km) chamber capable of providing simulated solar radiation pressure/temperature variations, and charged and active neutral species.

Both a plasma generator and cryogenic equipment will be needed to provide a means for obtaining great temperature extremes in the laboratory.

Finally, a high-vacuum chamber with both X-ray and ultraviolet sources will be necessary. ■

Representative Equipment Procurement

The following list is typical of major types of equipment to be procured for the Instrumentation Research Laboratory. Many changes can be expected, particularly in procurement late in the decade. Because of the nature of the laboratory and its heavy emphasis on bioscience and optical measurement, rapid advances in the state of the art will necessarily affect laboratory equipment needs. Small conventional laboratory equipment has been omitted from the list.

Frequency synthesizer
Portable spectrum analyzer
Liquid helium transfer tube
Sonic analysis system
Average transients computer
On-line correlation computer
1 kc-1.5 mc wave analyzer
1 kc-1.5 mc sweep drive wave analyzer
Transistor-curve tracer
Accessory null detector
Rotating coil gaussmeter
Megohmmeter insulation tester
Decade attenuator
Portable magnetometer
Rubidium vapor magnetometer
Linear velocity transducer
Linear displacement transducer
Microforce transducer
Electronic pressure heads
High-capacity flowmeter kit
Turbine flowmeter
Force-measurement proving rings
Triaxial accelerometer
Light-mike light sensor
200-1,000c IR black body
Direct-reading torsion balance
One-ton hydraulic table
Low-temperature vacuum chamber
Ultra-high vacuum system
High-temperature vacuum chamber
Hyperthermal tunnel
Control unit ionization gage
Macleod vacuum gage
Micrometeoroid Van de Graaff accelerator
Vacuum evaporator & ACC
Interferometer spectrometer
Vacuum UV spectrograph
Infrared spectrometer
Cycloidal residual gas analyzer
Microwelder
Test unit pulser
Small satellite computer
Medium satellite computer
10-liter liquid helium container
Liquid helium transfer tube
D-C logarithmic amplitude & voltmeter
Dual-cell rocket magnetometer
Single-tube standard manometer
Lab thermocouple
Force-measurement proving rings
Low-temperature vacuum chamber
Dual-purpose spectrometer
Resonance spectrometer
Laser microprobe
High-field superconductor magnet
Mass spectrometer

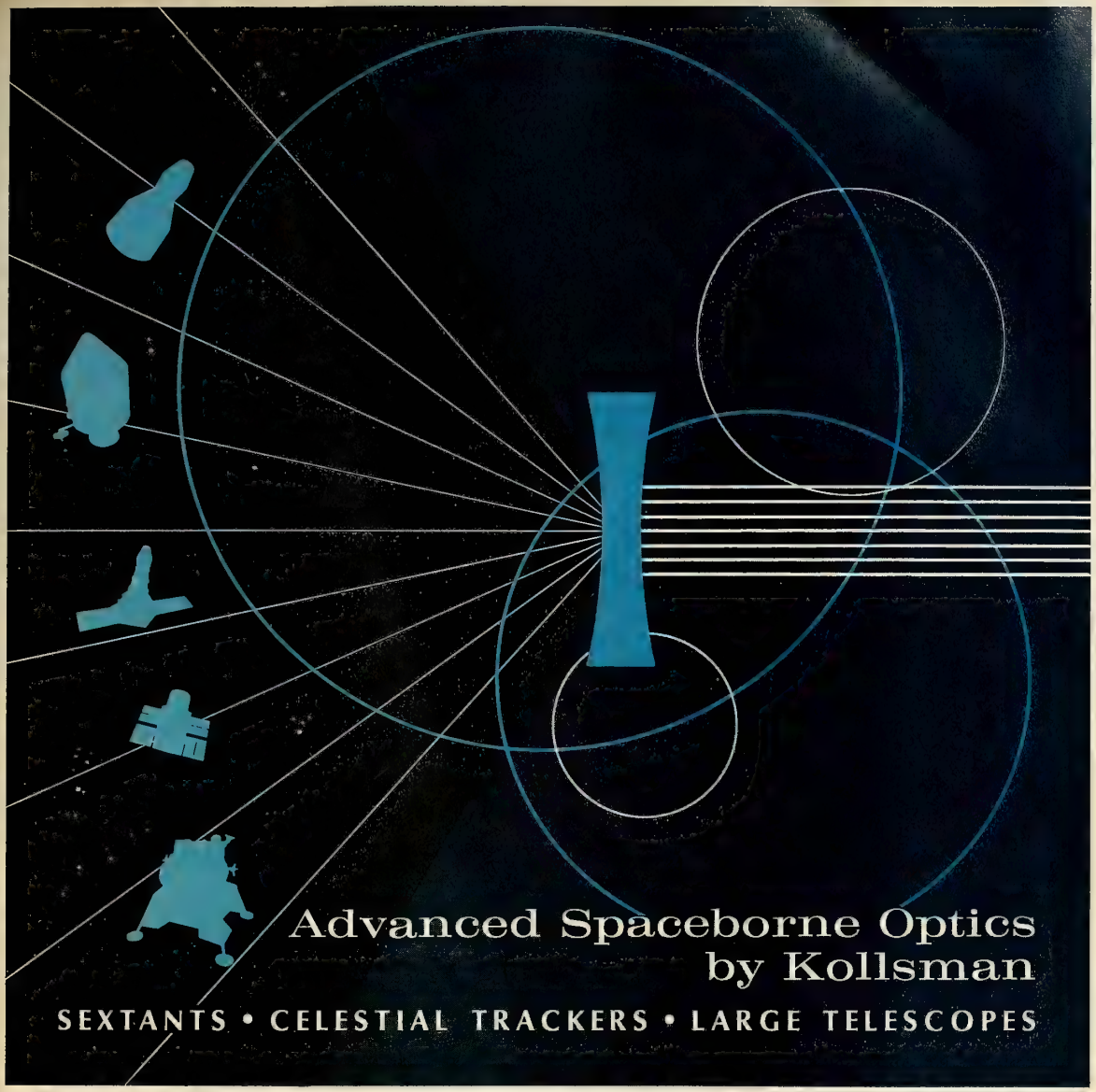
Space Optics Lab

THE SPACE OPTICS Laboratory is one of two within the Electromagnetics Research Division. As such, it is charged with the task of advancing knowledge and improving technology for both space and aeronautical applications of the optical portion of the electromagnetic spectrum. It will investigate both passive and active techniques for transmission, reception and storage.

For FY '66, total equipment procurement costs are expected to be $922,000 for 269 separate items. Nearly $892,000 will be required in FY '68 for an additional 158 items to initially supply the laboratory.

Construction costs are expected to total $2.1 million in FY '66 and $2.1 million in FY '68.

By 1970, the laboratory personnel



Kollsman's project-proven techniques have made a major contribution toward the exploration of the inner depths of outer space via advanced optical, electro-optical and electronic systems for manned and unmanned spacecraft of various types and sizes. The range of Kollsman capability in advanced spaceborne optics covers the complete spectrum from conception through development to production of guidance, navigation, scientific, sighting and simulation equipment. Kollsman's Space Division is successfully participating in significant NASA and Defense programs as prime and subcontractor. Some of these programs are:

■ *Celestial Trackers for the OAO* ■ *38 inch Diameter Optical Telescope and Spectrophotometer for Goddard Experiment Package* ■ *Guidance and Navigation Optical Subsystems for Apollo* ■ *Alignment Optical Telescope for LEM* ■ *Hand-held Space Sextant Experiment for Gemini* ■ *Ranger Spacecraft Model Simulator* ■ *Star Scene Generator and Viewing System* ■ *Space Position Fixing Technique Studies* ■ *Lunar Optical Subsystems* ■ *ALSS Optical Design Study (MOLAB)* ■ *Space Guidance System Studies* ■ *Solid-State Star Tracker* ■ *Large Optical Technique Studies for MORL.*

If your thinking is currently celestially-oriented, you would do well to think Kollsman, a leader in the field of large optical systems, space navigation and guidance, spaceborne payloads and experiments, space mission subsystems and components and simulation equipment. For more information write to Kollsman Instrument Corporation, Elmhurst, New York 11373.

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Experienced in the development and production of digital computers with emphasis on heavy ferrite core memory background. Knowledge of logic diagrams and corresponding electronic circuits is required, plus experience in welded modules and encapsulation techniques, analog circuit test and evaluation, micrologic and integrated circuit application. Should be able to effectively lead others.

COMPUTER MEMORY SPECIALISTS —
Experienced in design and development of non-destructive read-out memories. Background in multi aperture ferrite cores essential. Should be capable of directing a group in conceptual thinking and development of new applications for existing and future memory devices.

COMPUTER LOGICIAN —
Minimum four years experience in providing machine organization, logic design equations, coordinating diagnostic routines, and trouble-shooting programs for military type computers. Responsible for computer subsystem interface requirements. Familiar with algorithms used for arithmetic functions.

AIRBORNE COMPUTER PROGRAMMING —
Demonstrated ability to digest and apply programming techniques applicable to incremental techniques. Will program airborne digital computer for test and operation of system for pre-flight and in-flight equations and evaluate errors generated.

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force is expected to level off at about 140, primarily technical.

Principal research concentration within the laboratory will be in the area of laser technology—about 40% of the total effort. Emphasis will be in the field of communications for deep-space or space-to-space application. Materials studies will be included, as well as research into advanced techniques and communications theory.

Other major lab efforts will be in the fields of clear-air turbulence, high-resolution optical mapping and imagery, and general support for aerospace science in optics.

All laboratory efforts will be aimed at the post-*Apollo* period. ■

Representative Equipment Procurement

The following typifies major types of equipment that will be procured for the Space Optics Laboratory. Some changes can be expected, but since this laboratory is one of the three planned for first completion, the list is reasonably firm. Small standard optics laboratory equipment have been omitted.

Precision optical bench assembly
Photo-electric autocollimator
Laser power supply
4-joule-output laser system
Calorimeter
Kerr cell
Hendrix Interferometer
Alignment telescope
Microvolt scanning vacuum monochromator
Ballistic thermopile
Photon microvolt detector
Thermistor IR detector
He-Ne gas laser
Vacuum evaporator
10-in. Newtonian collimator
Infrared radiometer
Nephelometer
Pyrheliograph
Laser miscroscope
Digital computer
TV camera
TV monitor
1 kc-1.5 mc wave analyzer
Interferometer spectrometer
Grazing incidence spectrograph
Spectral recording densitometer
Time-resolved spectrograph
Infrared spectrophotometer
Laser microprobe
Analog computer
TV camera
TV monitor
Electronic high-intensity stroboscope
Phase comparator
High-voltage sine-wave generator
On-line correlation computer
Aerial camera
Kerr cell camera
Propagation research tank
Cycloidal residual gas analyzer

NEW

INSTRUMENTATION TELEVISION CAMERA

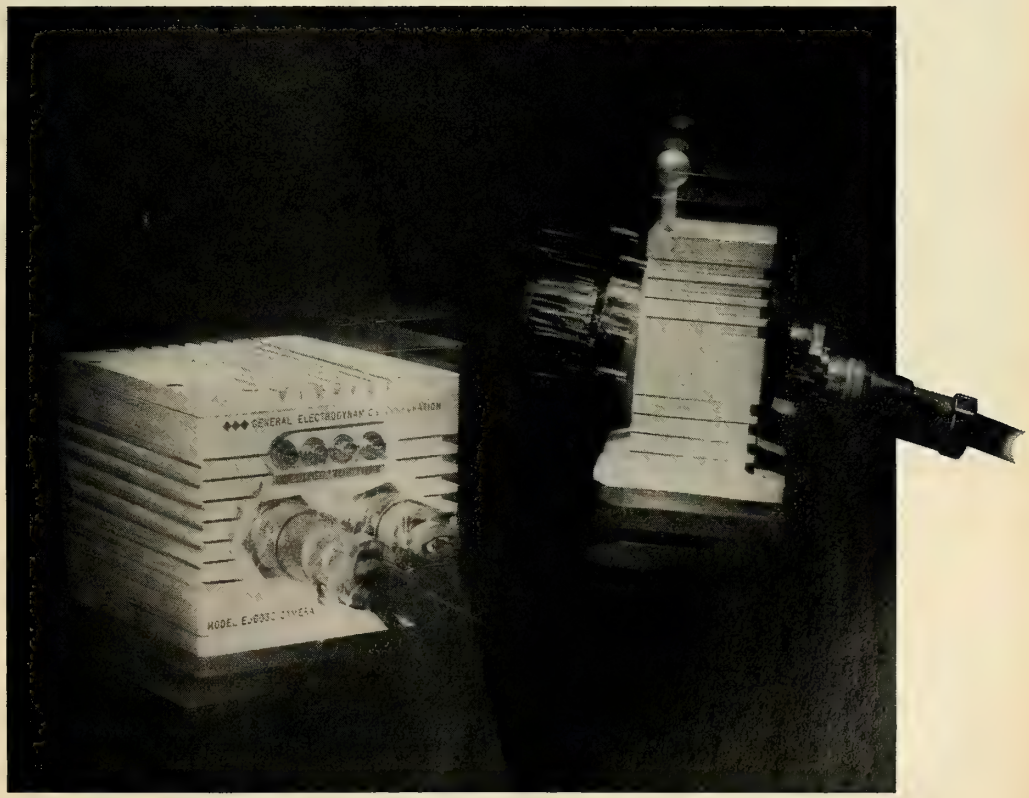
OPERATES IN EXTREME ENVIRONMENTS

The ED 6038 miniaturized instrumentation television camera was designed by General Electrodynamics Corporation to operate in the extreme environment existing within the engine compartment of the largest space boosters, such as Saturn. The high quality pictures produced during this severe environment will provide direct, real-time observation of events while they are happening.

This compact, light weight camera is available in a number of configurations with a wide selection of accessories from General Electrodynamics.

ENVIRONMENTAL CHARACTERISTICS:

- 20g RMS
- 60g RMS for 5 sec
- 20 cps — 2000 cps random
- Shock: 100g for 11 ms
- Altitude: Space environment
- Acoustical Noise: +175 db
- Temperature: —10°C to +71°C operating
  —10°C to +125°C non-operating
- Explosion Proof



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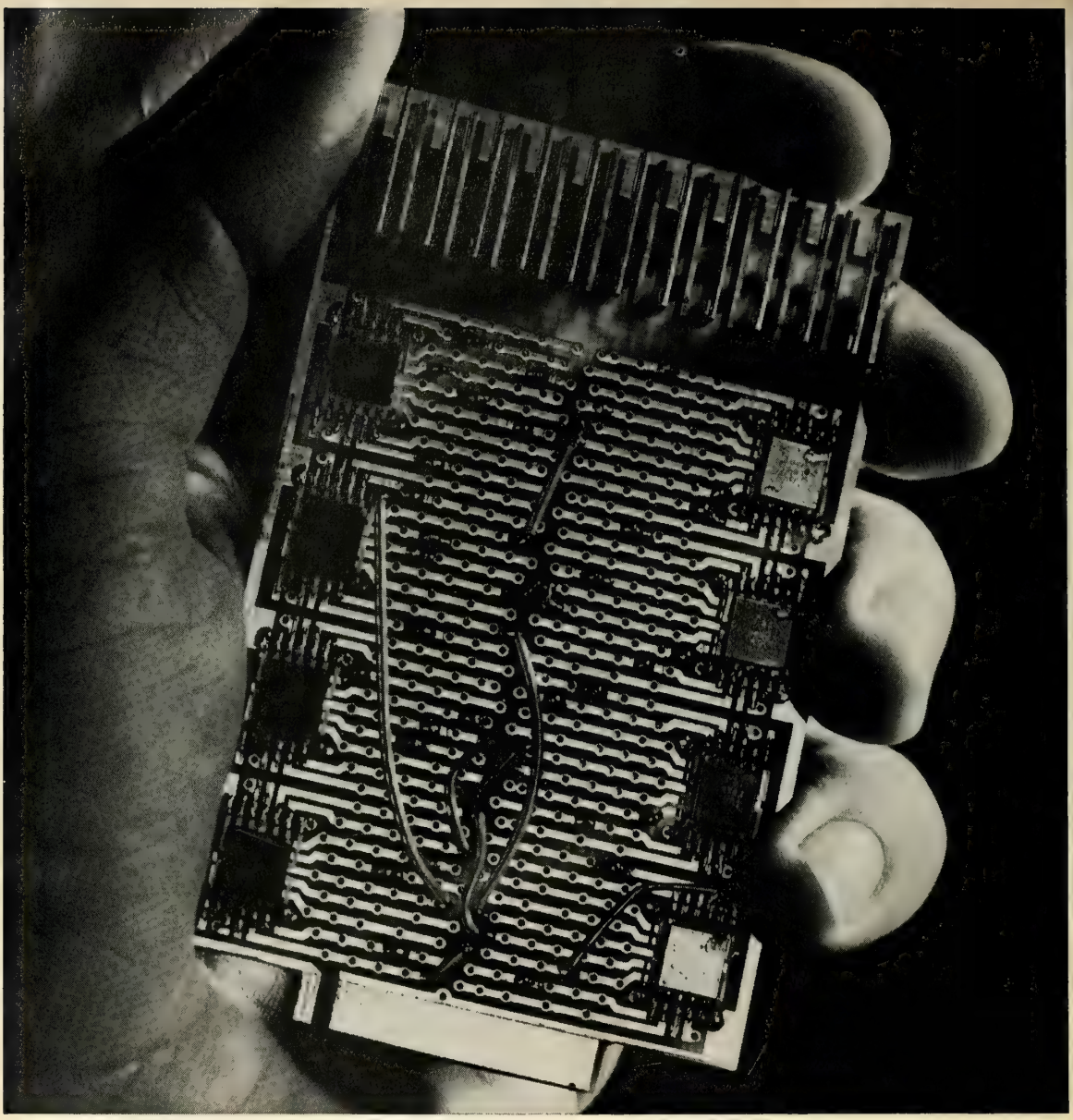

Careers on the move in **solid state electronics**

The Advance Electronics Department of the Douglas Missile & Space Systems Division offers challenging opportunities for physicists with interests and backgrounds in solid state devices. Since the work is of a fundamental nature, publication of results is encouraged. Specific areas of interest are:

Semiconductor and Thin Film Transport Phenomena ■ Electronic and Magnetic Measurements ■ Electronic Materials Properties ■ Device Concepts.

We prefer Ph.D.'s with backgrounds in solid state electronics and device physics. Send your resume to Mr. J.Y. Snodgrass,

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Power Conditioning and Distribution Lab Will Seek Better Electrical Systems

Thermal, plasma, chemical, solar and nuclear power conversion will be studied; equipment for two branches expected to cost $1.46 million through FY '69

THE POWER CONDITIONING and Distribution Laboratory (PC & DL) is part of the ERC Systems Division. Divided into two branches—Electronic Power Conditioning and Distribution and Regulation—the lab's objective is to improve space power systems, with initial emphasis on the electrical and electronic aspects of such systems.

The lab will procure equipment at a total estimated cost of $1,458,024—$799,543 programmed for FY '67 and the rest in FY '69. About 362 separate items will be purchased for in-house research and monitoring of contracted work.

It will be one of the last labs built in the ERC master plan. A total of $4.1 million is programmed for construction —$2.1 million in FY '67 and the rest in FY '69. When fully staffed by 1969, the personnel total will be 140.

● **Conditioning branch**—The Electronic Power Conditioning branch is responsible for analyzing the conversion of power generated for other purposes —such as propulsion—to electrical energy. Techniques will be studied for converting available sources of thermal, plasma, chemical, solar and nuclear energy to meet the requirements of electronic systems.

Basic and applied research will be conducted into the application of organic and inorganic compounds or elements to electrical power generation.

Research will be initiated into the applications of nuclear physics to the generation of electrical power for spacecraft electronics systems and support equipment.

The branch will also evaluate energy conditioning efficiency, source stability and regulation, packaging requirements and life expectancy to determine the feasibility and practicality of nuclear power sources for electronic use.

Test facilities and procedures will be established and maintained for the evaluation of electronic systems power sources. The branch also supplies performance data and correlates input-output requirements with electronics equipment designers.

● **Distribution branch**—The Distribution and Regulation branch concentrates on the research and development of power distribution systems. New systems will be analyzed to isolate problem areas and generate component technology requirements.

The branch also performs theoretical and experimental investigations into new techniques and materials for electrical wiring systems. Problems of skin effects, hysterisis losses and mutual coupling in electrical conductors and regulation devices will be treated.

An effort will be made to integrate new wiring developments with electronics equipment design and to supply test and evaluation data to potential users.

Basic and applied research will be directed to the causes and effects of conducted radio frequency interference. There will be investigations into problems of frequency selection or assignment, spurious signal interference and parasitic suppression techniques.

The branch will study power distribution systems to determine optimum frequencies, voltages, and current ratings for space electronics systems. Problems of size and weight, stability, regulation and reliability in power distribution equipment will be studied. The branch will generate and publish standards for systems designers. ■

Representative Equipment Procurement

The following list is characteristic of the type of equipment being procured for the PC&DL. It is not complete, but serves to indicate the depth of in-house and contracted research assigned to the lab and its branches. Common items such as recorders, ammeters and other fairly standard electronic laboratory equipment have been omitted. The list is by no means firm, since changes can be made until completion of the lab.

Temperature and humidity chamber
Thermal vacuum chamber
Solar simulator, source only
Data asquisition system
Interferometer
Measuring comparator
X-ray electronic fluoroscope
Crystal identification goniometer
X-ray diffraction equipment
Leak-detection apparatus
Precision metallograph
Photo-electric autocollimator
10-in. Newtonian collimator
Spray etcher
Small satellite computer
Calorimeter
Vacuum spectrometer
—100° to 1,000°F temperature chamber
Ultra-high vacuum gage
Frequency synthesizer
Small satellite computer
High-temperature vacuum furnace
Thermal vacuum chamber
Phase comparator
Temperature chamber
Salt spray chamber
100-kw solar power array
12 in. and ACC precision magnet
Portable salinometer
Rotating coil gaussmeter

Microwave Radiation Laboratory To Cost $5.9 Million by FY '68

Unit will be responsible for extending technology in microwave portion of spectrum; early work to emphasize deep-space communications; personnel peak of 150 expected by 1970

THE MICROWAVE Radiation Laboratory is one of two laboratories comprising the Electromagnetic Research Division. It is charged with the task of advancing knowledge and improving technology for both space and aeronautical applications of the microwave portion of the spectrum and will serve as a collecting point for all state-of-the-art data covering the region from 10 cm. to 0.1 mm.

For FY '66, total equipment procurement expenditures are expected to be $1,317,333 for 765 separate items. In FY '68, an additional $1,457,713 will be required to procure 427 items of equipment. Total equipment expenditures to initially equip the laboratory will be $2,775,046, the agency estimates.

Construction costs are expected to total $3 million in FY '66, $1.9 million in FY '67, and $1 million in FY '68.

The total laboratory personnel force will reach 140-150 by 1970 and level off at that time.

While the principal early task of the laboratory will be in the field of advancing deep space communications, it is expected to maintain a fairly even distribution of effort in all phases of microwave technology.

Research will be directed toward major improvement in space and atmospheric and supporting ground communications for manned and unmanned missions. It will also provide microwave technology support for the fields of radio astronomy, meteorology and aeronomy.

Theoretical studies, materials research, advanced component and circuit development, and prototype system development are provided in the laboratory's charter. Besides providing general support for advancing aeronautical microwave systems capability, the lab will maintain an effort directed toward solving the clear-air turbulence (CAT) problem encountered by high-altitude, high-speed aircraft.

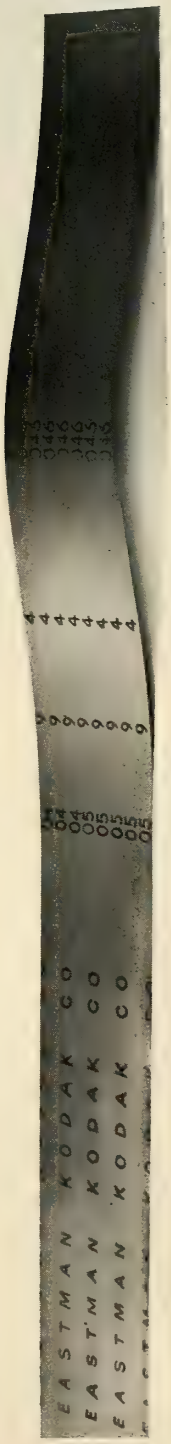
All laboratory efforts will be aimed at the post-*Apollo* period (1970 and on) except the CAT detection program (three to five years). ■

Representative Equipment Procurement

The following is typical of major types of laboratory equipment that will be procured for the Microwave Radiation Laboratory. Some changes can be expected, but since this laboratory is one of the three planned for first completion, the list is reasonably firm. Small standard microwave and millimeter wave laboratory equipment have been omitted.

Phase comparator
Wave analyzer
Low-frequency function generator
Electronic counter digital recorder
Microwave power meter
53-90-gc harmonic generator set
Interference microscope
Broadband microwave receiver
Sonagraph
Frequency synthesizer
Electronic stroboscope
Bridge oscillator
Portable millivolt potentiometer
Rotating coil gaussmeter
0.5-54-mc receiver
VLF receiver
Loran receiver
Microwave spectrum analyzer
Portable spectrum analyzer
Argon noise source
Neon noise source
Klystron power supply
Elevation azimuth antenna mount
Single-side-band spectrum analyzer
Digital clock programmer
Average transients computer
On-line correlation computer
Optical comparator
Photo-electric autocollimator
Visual autocollimator
Wide-range receiver
Antenna pattern recorder
Radiation distribution printer
Multi-axis antenna positioner
3-axis antenna position indicator
Sine-square-wave generator
Antenna pattern integrator
Transmitting 8-ft. antenna
Average transients computer
On-line correlation computer
Two-way FM radio
Microwave test set
Telemetering indicator
Frequency standard
Sonograph
Frequency analyzer
Digital clock programmer
Low-temperature vacuum chamber
4-in. high vacuum pumping system
Hyperthermal tunnel
Small satellite computer
9-in. auto record microdensitometer
Time resolver spectrograph
Hendrix interferometer

Soon all data tape recording will be "done by the numbers"



CEC Magnetic Tape, created and produced by Eastman Kodak, has virtually eliminated every tape problem in data recording.

The secret begins with traceability

All CEC tape is *numbered*—color-coded on the box, can, reel; even digitally numbered on the back of the *tape* itself for instant identification.

For example, on every 15 inches of tape there appears an internal Kodak reference number which immediately identifies the tape by type; and every 30 inches there is a numbered tape signature which provides an index to the coating and test records for that particular production block.

This provides several obvious advantages to the user. A specific run of tape may be immediately located and identified. No longer need a mixup in reels become a problem or delaying factor. So efficient is this coding method, it is possible —through the numbers on the tape, reel, can or box—to trace any roll of tape all the way back to the master web from which it came.

However, digital coding is only one of the significant reasons why CEC Magnetic Tape is rapidly changing the state-of-the-art.

CEC tapes are divided into *four* specific categories. Collectively, they meet the most advanced requirements of *every* data recorder. Yet each tape records at the highest applicable resolution and sensitivity—with the greatest uniformity and lowest tape and head wear obtainable today.

In addition...

⊡ Only CEC tapes provide a standard nomenclature for simplified identification and ordering: S-1 standard, 100 kc; SX-1 standard extended, 300 kc; M-1 medium band, 600 kc; W-1 wide band, 1.5 mc.

⊡ Only CEC tapes are so precisely differentiated that users are no longer subjected to the time-consuming burden of performance evaluation.

⊡ Only CEC tapes come shielded in metal containers — packed in cardboard filing boxes covered with protective plastic sleeves.

⊡ Only CEC tapes are protected from shipping and storage damage by means of a plastic waffle hub, thus preventing tape serration and flange deformation.

However, with all these advantages, CEC Instrumentation Tape costs *no more* than the tape you are now using.

Write now for your free CEC INSTRUMENTATION TAPE CHART. This special chart lists CEC tape categories, applications, and models of recorders for which each tape is recommended. Ask for CEC Chart DM-47-X15.

CEC
Technical Supplies Department

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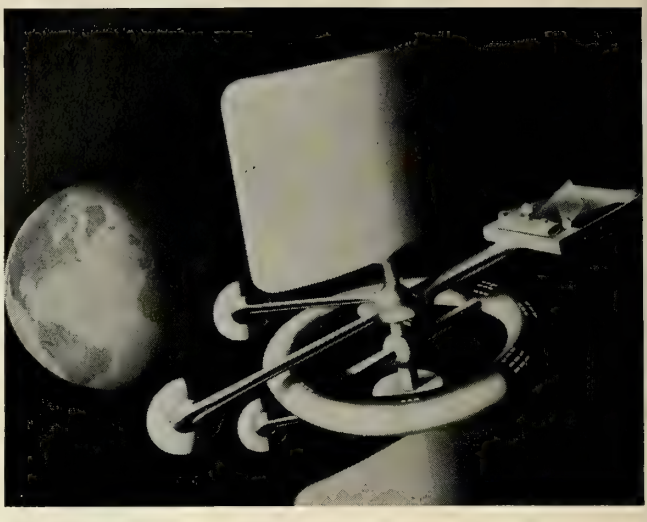

See!

1955—Special Defense Projects Department established (Now the Missile and Space Division); **1958 MARK 2*** — First operational heat sink re-entry system; **1958 ABLE** — First successful ablation flight over full ICBM range; **1958 MARK 2 DATA CAPSULE*** — First payload recovery from space; **1959 RVX-1*** — First vehicle recovery after ICBM flight; **1959 MARK 2 SPACE LAB** — First 3-axis (individually) stabilized vehicle; **1959 MARK 2 SPACE LAB*** — First photos from space; **1960 MARK 3** — First operational ablation re-entry system; **1960 MARK 3** — Longest re-entry system flight in the world (9000 miles); **1960 DISCOVERER*** — First recovery from orbit; **1960 NERV** — First recovery from Van Allen Belt; **1961 NIKE ZEUS TVX** — First full-scale vehicle to transmit telemetry throughout re-entry; **1963 MARK 6** — Largest operational weapon re-entry system in U.S. arsenal; **1964 MAGS** — A unique gravity gradient stabilization system (damper and system analysis for USNRL flight); **1964 NIMBUS** — Design, test and flight of the free-world's first 3-axis stabilized earth oriented weather satellite; **1964 RMV** — First successful flight test of an ICBM re-entry system utilizing an all-inertial attitude control and measurement system.

*Exhibited in the Smithsonian Institute

On the eve of our tenth anniversary, let's look forward: Orbiting Astronomical Observatory; Biosatellite; Mark 12 Re-entry System for Minuteman; a Maneuverable Ballistic Re-entry System; a stabilized and controlled re-entry target system (Re-entry Measurement Vehicle); a second Nimbus and MAGS; a study of an unmanned spacecraft (Voyager) for the exploration of Mars; and the study of a Manned Orbiting Laboratory (MOL) are some of tomorrow's programs being performed today by General Electric's Missile & Space Division.

We need men right now to help cope with the problems we expect to solve in the next 10 years . . . scientists and engineers who can offer significant experience in: guidance and control systems . . . systems analysis . . . systems simulation . . . materials development . . . structural design . . . project engineering . . . guidance and control equipment design . . . radar discrimination . . . computer programming . . . test engineering . . . reliability . . . IR/optics . . . electronic sensors . . . electro-chemistry . . . nuclear power (SNAP) . . . radiation effects.

Interested applicants are invited to inquire further by writing to Mr. J. S. Barson, Dept. 394E-5, Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia 1, Pa. An equal opportunity employer.

MISSILE & SPACE DIVISION

GENERAL ELECTRIC

Reliability Is Components Lab Mission

Lab's responsibility will give its four branches strong priority in personnel recruitment, facilities construction

THE ELECTRONICS Components Laboratory is assigned to the Component Technology Div. (CTD) at ERC. The lab has four branches—Solid-state, Materials, Vacuum Devices and Electromechanical.

The estimated cost of equipping this lab and its branches is expected to reach $2,468,785, with $1,452,141 programmed for FY'65 and the rest in FY'67. A total of 745 items will be purchased.

The total cost of constructing the lab will be $5.2 million and its personnel complement at full operation is expected to reach 210 people.

The main, immediate purpose of this laboratory is to improve the reliability of individual components, giving it a high priority in recruiting and construction.

The lab will provide facilities and management and run research programs in all aspects of electronic components—with emphasis on component operation in the space environment.

● **Solid-state Branch**—The Solid-state Branch will focus on new techniques and devices in the field, such as thin films and microelectronics. A second objective is to improve the simplicity and reliability of operational systems.

The basic and applied research aspects of the field will be studied by the branch with a view to the creation of new circuit elements, including tunnel diodes, field-effect transistors and negative resistance devices.

Spacecraft systems concepts will be analyzed to determine ways to improve the state of the art in solid-state electronics.

● **Materials Branch**—The whole area of materials in electronic applications will be handled by the Materials Branch. Basic and applied research programs will determine properties such as dielectric constants, conductivity, tunneling effects, insulation properties and dissipation and permeability characteristics as they apply to materials.

New or unique materials advancements will be investigated for their usefulness in electronic applications. Methods and practices will be established to improve handling, fabrication, reproducibility and reliability.

The branch will also provide research and test facilities for the verification of new materials developments.

● **Vacuum devices branch**—The Vacuum Devices branch will concentrate on extending the technology of vacuum tubes. New techniques and devices such as slow wave structures and crossed field effects in extreme vacuum conditions will be studied for application to tube technology.

The use of phosphors and other electroluminescent materials in display devices, and their stability and efficiency as functions of the vacuum environment, will be researched.

New methods of formulating glass suitable for use in the space environment will be pursued, as will improvements in tube envelopes and other glass encapsulation problems.

● **Electromechanical branch**—Electromechanical improvements such as techniques in upgrading the performance of servo elements will be handled by the Electromechanical Branch. The applications of new lubricants and lubricating techniques will also be a part of the work at this branch.

Methods for attaining higher accuracies in precision servo-control concepts through the use of frictionless devices, improved materials, digital encoding and size and mass reduction schemes will be generated as the branch expands.

Efforts will be directed at increasing the efficiency and accuracy of components serving as transfer devices between mechanical, pneumatic or hydraulic systems and electrical control systems. ■

Representative Equipment Procurement

The Electronic Component Lab will purchase some 745 items of apparatus, including the representative list below. The devices are listed to indicate the type and depth of both in-house and contracted research expected to form the main contribution of this lab. The list is not complete and such common equipment as oscilloscopes, cameras, benches and recorders have been omitted.

High-temperature vacuum furnace
Residual gas analyzer
Wave analyzer
Rotating coil gaussmeter
Diffusion furnace
Medium computer
Solid-state laser
Ruby laser rod
Vacuum leak detector with pump
Crystal-growing equipment
Electron microscope
X-ray diffraction equipment
Organic combustion furnace
Calorimeter
Spectrophotometer
Nefluoro photometer
Gas chromatograph
Infrared spectrometer
X-band spectrometer
Ultraviolet spectrometer
X-ray diffraction equipment
Neutron flux monitoring system
Argon noise source
Laminar flow bench
Vacuum firing station
Micro cutter-welder
Device evaluation system
Phase comparator
Transistor test set
Digital recorder
Rotating coil gaussmeter
Ultra-high vacuum gage
Cryogenics refrigeration system
Thermal conditioning apparatus
Electron microscope
Residual gas analyzer
Thin-film monitor
Mask alignment system
Positive ion accelerator
Ion beam system
Electron-beam melting furnace
Electron microscope
10-12-vacuum cryopump
Joule laser system and power supply
50-k magnet system

Qualifications & Standards Lab Will Codify Environmental Testing Methods

Three branches—Environmental Testing, Standards and Design Criteria—will require $3.22 million to equip by FY '68

THE CORE LABORATORY of the ERC is the Qualifications and Standards Laboratory in the Component Technology Division. It provides for facilities and for broad programs in all aspects of advanced reliability-environmental-standardization techniques and the establishment of NASA-wide qualified electronics products lists.

The lab has three branches—Environmental Testing, Standards, and Design Criteria. Current plans call for expenditure of $3,222,233 to fully equip the laboratory. Broken into three fiscal-year increments, equipment costs will run to $1,366,973 in Fiscal Year 1965, $1,246,044 in FY '67 and $709,216 in FY '68. Plans call for 1,112 pieces of apparatus.

Total construction costs will reach $7.1 million through FY '68. The lab will have 68,000 sq. ft. of floor space and, at full complement, will employ 200 scientists, engineers and technicians.

Besides the agency-wide products listings, the lab will also generate and document a unified program of environmental testing methods and procedures for all of NASA.

- **ETS**—The Environmental Testing Branch maintains an environmental facility for testing components and small subsystems in conjunction with the Standards Branch.

These facilities are also available to all other labs at the center whose testing needs are common to this branch, but not so voluminous as to require separate physical installation.

This branch is also responsible for selection, design, development and installation of all environmental testing equipment throughout the center. In addition, research and development will be aimed at methods of conducting simultaneous testing of multi-environments as well as creating new, as yet undetermined, environments.

- **SB**—The Standards Branch will coordinate with other NASA field centers and Headquarters to conduct a through analysis of all space-electronic failures in NASA and other government agencies.

Using this data, it will determine priorities in obtaining standard NASA components.

This branch also serves as the focal point for the generation and distribution of electronic parts lists reflecting qualified components for NASA applications. It will direct those tests conducted by the Environmental Testing

Representative Equipment Procurement

The brief list below is characteristic of the 1,112 items of apparatus destined to be housed in the Qualifications and Standards Lab. The compilation indicates the type and depth of in-house and contracted research handled by the lab and its branches. Common lab items such as recorders, furnaces and standard measuring devices have been omitted.

Satellite hybrid computer
Thermal-vacuum chamber
Vacuum-test chamber, ascent
Cryotemp chamber
Altitude chamber
Salt-spray chamber
Integrated-circuit assembly machine
Wafer scriber
Precision-reduction camera
Photo repeater
Precision comparator
Mask alignment system
Semiconductor slice breaker
Diffusion furnace
Filament-heating vacuum evaporator
Optical pyrometer
Audio spectrometer
Interference microscope
High-temperature furnace
Dynamically controlled welder
Sheet-metal punch
Arbor press
Milling machine
Bench lathe (10-in.)
Gas welding outfit
Milling machine
Electron-probe microanalyzer
Emission spectrograph
Vacuum spark mass spectrograph
Infrared spectrometer
Vacuum spectrometer
Electron-beam scanning console
Universal spectrophotometer
Spectrophotometer circuit-panel
Small digital computer
Frequency doubler
Integrated circuit tester
Electronic fluoroscope
Interferometer
Micro hardness tester
Precision wenner bridge
Anthony-pattern bridge
Standard-frequency multiplier
Time-calibrator oscillator
Variable delay lines
Electronic-counter digital recorder
Mass spectrometer
Vacuum bridge
Electronic stroboscope
High-intensity electronic stroboscope
Wave analyzer, 1kc-1.5mc
Wave analyzer, 1kc-1.5mc, sweep drive
High-temperature vacuum furnace
Analytical spectrometer
Dual-purpose spectrometer
Analog/digital converters
Pulse analyzer, 400 channel
Neutron-flux monitoring system
Autoclaves
Frequency divider & clock
Vacuum test chamber
Thermal-vacuum chamber
Solar simulator
Small-size digital computer
Cryogenic storage circ & dist system

PARTNERS

The Minuteman missile stands its watch on land. But its technology can also lend a hand on the flight decks of U. S. aircraft carriers far at sea—or at forward airstrips.

Microelectronics advances pioneered by NAA/Autonetics for Minuteman II are now being developed for Autonetics avionics systems providing pre-flight and in-flight checkout for carrier-based aircraft. The result will be less deck clutter. Clean flight lines. Simplified maintenance. Lower maintenance costs.

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North American Aviation Autonetics Division

Branch associated with the NASA standard components program.

● **DCB**—The Design Criteria Branch originates and manages programs aimed at enhancing reliability and performance by studying electronic design criteria and establishing compatibility criteria. Methods and new concepts will be developed for reliability-testing of components and for performing failure-mode and failure-rate studies.

Sampling and testing procedures for electronic equipment will be studied, and system and error analyses performed.

The branch determines the impact of constantly updated and expected environments on current and future electronic components. Results of the reliability and environmental condition studies will be adapted into sound space electronics design criteria.

A basic mission of this branch is to provide as much information as possible to help component, subsystem and systems designers introduce reliability into electronic equipment in the conceptual stages. ■

PART III: ERC LABORATORIES & EQUIPMENT

Control, Information Systems Lab To Cost $3.5 Million, Employ 180

THE CONTROL and Information Systems Lab, part of ERC's Guidance and Control Division, provides facilities, management, planning and programming for all aspects of vehicle control and stabilization and information systems.

The lab equipment costs are estimated to be $1,446,010, all to be procured in FY '67. Lab construction costs are programmed at $3.5 million in the same fiscal year. At full operation, there will be some 180 people on the staff using some 55,000 sq. ft. of floor space.

The lab has three branches—Control Systems, Control Theory and Control Devices.

● **Control Systems Branch**—The Control Systems Branch studies and analyzes new concepts of system configurations to determine component technology requirements. Study programs are under way to optimize the interfaces between man, machine and environment and to make maximum use of man's judgment and decision-making powers so that equipment research can optimize informational sources, vehicle control characteristics and decision-aiding devices.

Experimental research will be directed toward derivation of techniques and procedures for utilizing forces inherent both in the space environment and in vehicle characteristics for component pointing, vehicle orientation, orbit maintenance and trajectory adherence.

This research seeks full understanding of the planets and their satellites, their spheres of influence and magnitude. Phenomena such as radiation pressure, gravity gradient and magnetic field will be investigated with an eye for discovering means of capitalizing on these forces for vehicular control.

Control system concepts optimizing the use of on-board power generation or conversion systems for control functions will be examined. The research program will consider hybridization and the use of waste products, energy and propellant sources and effects on vehicle configuration in the establishment of optimum control systems for given environments.

● **Control Theory Branch**—The evolution of mathematical methods of producing, analyzing and synthesizing dynamic control and information processing systems will be the responsibility of the Control Theory Branch. Unpredictably changing environments will be considered.

Mathematical processes will be generated to examine dynamic performance characteristics of various control concepts as applied to linear, non-linear, stochastic and indeterminate processes.

Representative Equipment Procurement

There will be some 831 items of lab apparatus procured for the Control and Information Systems Lab. These items are not final, but changes are expected to be minor. Teletypewriters, recorders, oscilloscopes and other more-or-less standard lab equipment have been omitted from this brief list. The items below are representative only.

Graphical digitizer input device
Digital plotting system
Data acquisition system
Small satellite computer
Hybrid computer
Jet actuator test facility
Force coupling device
Cryogenic test facility
Hydraulic system
Liquid helium II cryogenic containers
Liquid hydrogen cryogenic container
Liquid helium I cryogenic container
Liquid nitrogen cryogenic container
Liquid oxygen cryogenic container
Annealing furnace
Controlled atmosphere furnace
High-temperature vacuum furnace
Tube tester vacuum bridge
15-15,000-cps phase comparator
Universal linear operator
Multiplier/divider
Low-frequency function generator
Fast pulse generator
Pulse generator
Signal generator
Phase comparator
Wave analyzer
Sweep drive wave analyzer
250cps-100kc telemetry oscillator
Miniaturized telemetry transmitter
Quiet rooms
3-axis simulator
Digital continuous system synthesizer
Ultra-clean work station
Ultrasonic cleaner
Roundness-measuring instrument
Photo-electric autocollimator
Camshaft tester
Interferometer
Vacuum bridge
Recording scleroscope
Laboratory microscope
10 circuit switching unit
Torque standard

These systems are characterized by their ability to improve performance through repeated exposure to input parameter variation, by adaptive or intelligent means.

Novel analogues of abstract control theory—which improves its understanding for the purposes of increasing its use in the practical sense—will be sought.

● **Control Devices Branch**—Concentrate on new and improved control and stabilizing concepts for space vehicles will be the Control Devices Branch. Methods for improving control signal processing and vehicle control systems will be studied.

Research programs into the transmission of information from machines to aircraft and spacecraft crew and control center personnel will be funded as well as the devices used to stimulate systems.

Man's sensory system will be studied to devise better display techniques for both vehicles and simulators. The technical requirements for manual and automatic insertion of control parameters and for all kinds of control computers will be investigated by this branch.

Devices for controlling energy flow for positioning vehicle elements to achieve and maintain desired trajectories will be of interest to this lab.

Flight experiments will be planned and implemented where required to verify analyses and experiments. ■

Electronics Research Center Telephone Directory

Area Code 617
Telephone 491-1500
575 Technology Square
Cambridge, Mass. 02139

EXT.	ORGANIZATION
443	**ARONIS, Paul** ... Component Technology Lab.
403	**BACH, Christine** ..... Computer Research Lab.
376	**BARONE, Vivian** ..... Personnel Branch
456	**BEATTY, Rosemary** ..... Qual. & Stands. Lab.
435	**BEBRIS, Janis** ..... Space Optics Lab.
255	**BENNETT, William** ..... Personnel Br.
495	**BONANNO, Stanley,** Administrative Services Br.
447	**BOYD, Ruby** .... Component Technology Lab.
440	**BOYLAN, Mary** ..... Electromagnetic Research
445	**BROUILLET, Norma,** Electronic Components Res.
431	**BROWN, Jean** ..... Microwave Radiation Lab.
241	**BROWN, Patricia** ..... Director's Office
412	**BURKE, Thomas** ..... Computer Research Lab.
206	**BUXBAUM, Jane** ..... Facilities & Eng. Ofc.
268	**CAHALANE, James** ..... Procurement Branch
224	**CALIO, Anthony** .... Research Engineering Br.
223	**CANAL, Albert** ..... Research Engineering Br.
223	**CARTWRIGHT, Michael** .. Res. Engineering Br.
414	**CARUSO, Anthony** ..... Instrumentation Lab.
204	**CASS, James** ..... Facilities Branch
268	**CASSIDY, Pauline** ..... Procurement Branch
444	**CLARKIN, Philip, Dr.** .. Component Tech. Lab.
455	**CLINE, James, Dr.** .... Qual. & Stands. Lab.
465	**COLELLA, Albert,** Control & Inf. Systems Lab.
489	**COLEMAN, William,** Programs & Resources Ofc.
494	**COLLINS, Dennis, Jr.,** Con. & Inf. Systems Lab.
496	**CUMMINGS, Thomas** .. Administrative Serv. Br.
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264	**FLAVIN, Patricia** ..... Procurement Branch
254	**GAFFNEY, William** .. Management Analysis Br.
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488	**KELLEY, Ann** ..... Programs & Resources Ofc.
468	**KELLEY, Joan** ..... Guidance Laboratory
324	**KILLAM, Joyce** .... Programs & Resources Ofc.
222	**KINSELLA, Lawrence** .... Res. Engineering Br.
327	**KITTREDGE, Howard** Marshall Qual. Assur. Fld. Ofc.
205	**KNUTKOWSKI, Frank** ..... Facilities Branch
241	**KOCK, Winston E., Dr.** ..... Director
492	**KOVATCH, George, Dr.** Control & Inf. Systems Lab.
254	**LAWRENCE, Alex, Jr.** Management Analysis Br.
379	**LEACH, Nancy** ..... Personnel Branch
492	**LEARY, Marie** .. Control & Inf. Systems Lab.
414	**LEAVITT, William, Dr.** .. Instrumentation Lab.
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On-Board Velocity Meter Tested

DUARTE, CALIF.—Tests on an experimental plasma velocity meter have shown it to provide a feasible on-board method for measuring re-entry vehicle velocity during the plasma blackout period at altitudes of 30-80 mi.

Sponsored by the Flight Dynamics Laboratory, Wright Patterson Air Force Base, development of the meter has been carried out by Giannini Controls Corp. Accuracy is reported to be 5%, with improvement to be expected if flight tests are carried out to develop calibration procedures.

Max Lipscomb, chief of the Flight Dynamics Lab, says that if the technique were developed into a flyable instrument, its greatest value would be from Mach 16 up to super-orbital speeds. Pressure-measurement techniques do not provide reliable velocity data in this range.

● **Likely application**—The plasma-velocity measurement technique will be most valuable for gliding re-entry profiles, since inertial instruments give adequate control during the short period of ballistic re-entry.

Main parameters required for spacecraft re-entry control are angle of attack, side slip, velocity and density rate. The plasma technique indicates spacecraft velocity relative to the air mass it is moving through, and also gives some angle of attack data.

Other potential sources of velocity data investigated by the Flight Dynamics Lab have included the pressure distribution over a nosecone, the temperature distribution, and the temperature rate at the nosecone.

The laboratory is concerned with developing technology to advance the state of the art of flight control and to make measurements where measurements have not been possible before, Lipscomb says. The plasma test equipment, developed by Giannini to explore other flight-control uses for the plasma generated around the vehicle, is now being installed.

Further development of the plasma velocity meter would involve design of hardware for flight testing, but this probably will not be carried out until the Air Force has a mission requirement for glide vehicle instrumentation.

James R. Rochester, the senior physicist at Giannini concerned with developing the new technique, believes a flyable instrument could be produced, although parts such as the power supply have not been suitably packaged yet.

● **How it works**—The basic principle of the velocity meter is to create a disturbance in the plasma around the vehicle and measure the time taken for the disturbance to move past a section of the vehicle.

A magnetic pulse is used to create an ion wave in the plasma. This moves through the plasma with a characteristic velocity (similar to an acoustic velocity) that has to be corrected for. It is, however, a second-order correction at the re-entry velocities of interest.

Velocity of re-entry is normally about 7×10^5 cm/sec. The present range of the plasma velocity meter extends from 3×10^5 to 7×10^6 cm/sec., although higher-velocity measurements are believed possible with modification of the equipment.

The flow around the vehicle is an ionized laminar plasma. A disturbance is produced in this by means of a 5-microsecond magnetic pulse, which slows the plasma flow in a local region and sets up a density wave that travels downstream. Two plasma-density detectors on the side of the vehicle time the interval required for the density wave to travel from one to the other. Vehicle velocity is computed from the delay time.

Plasma densities were 10^6 ions/cc in early laboratory tests. These were later raised to 10^9 and then to 10^{13-14} ions/cc. The actual ion density that can be expected around a vehicle depends on its shape, increasing with its bluntness.

● **Probing the plasma**—Measurement of plasma density is made with two capacitive probes. Each probe has two plates that are exposed to the plasma, and an RF signal is propagated between them. The plates are coupled to a capacity bridge that will detect changes greater than 10^{-16} Farads. An a-c-coupled three-terminal bridge is used.

A change in the dielectric constant and conductivity occurs as the ion wave passes the plates. The bridge has detected a strong change in both of these during experimental runs.

The magnetic pulse is generated by a 10-kv system that delivers 5,000 amps into a 20-turn coil.

In the current configuration of the velocity meter, a C-magnet has the 20-turn coil wound around its mid-section. Its two end faces are flush with the surface of the spacecraft. The first capacitive probe is about six inches downstream and the second probe about 18 in. beyond that. The capacitive bridge operates at 10 mc. ■

Plasma Arc Facility Aids in Re-Entry Studies

TWO AVCO CORP. officials examine 2-Mw plasma generator from the firm's new ROVER plasma arc facility (tank at left). The facility makes possible the simulation of heating profiles of space vehicles either entering planetary or re-entering Earth atmosphere. Argon arc generators simulate radiation heating encountered in such hypersonic entry/re-entry situations.

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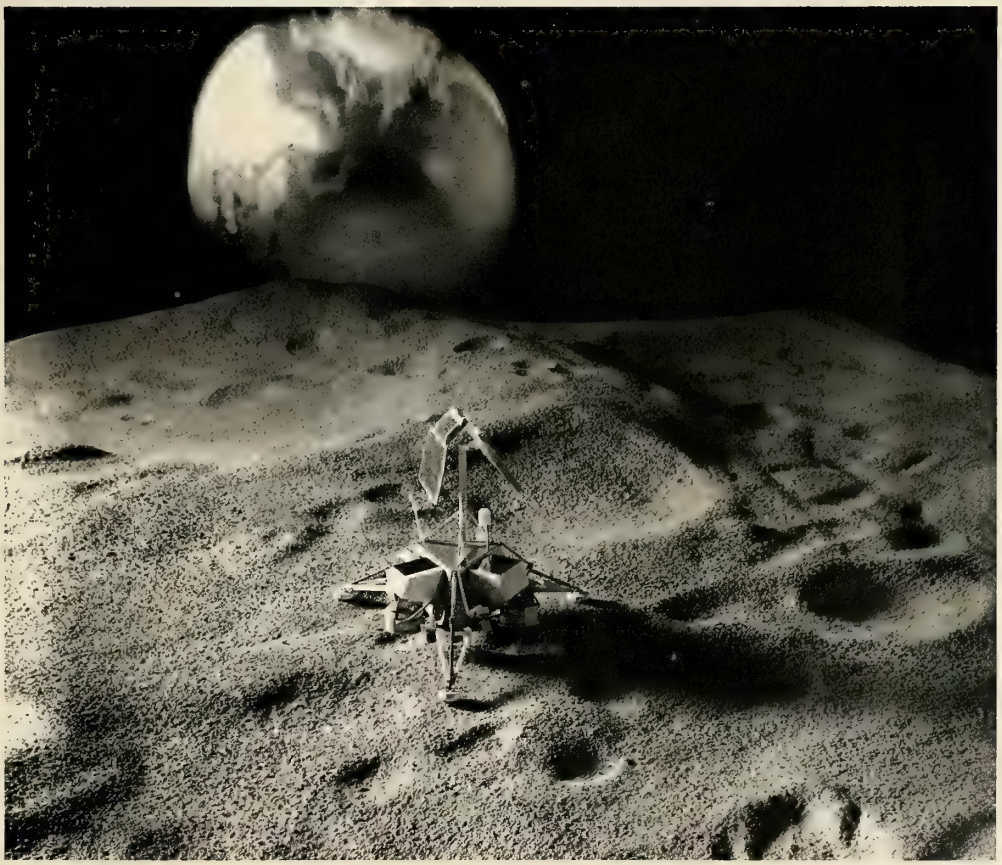

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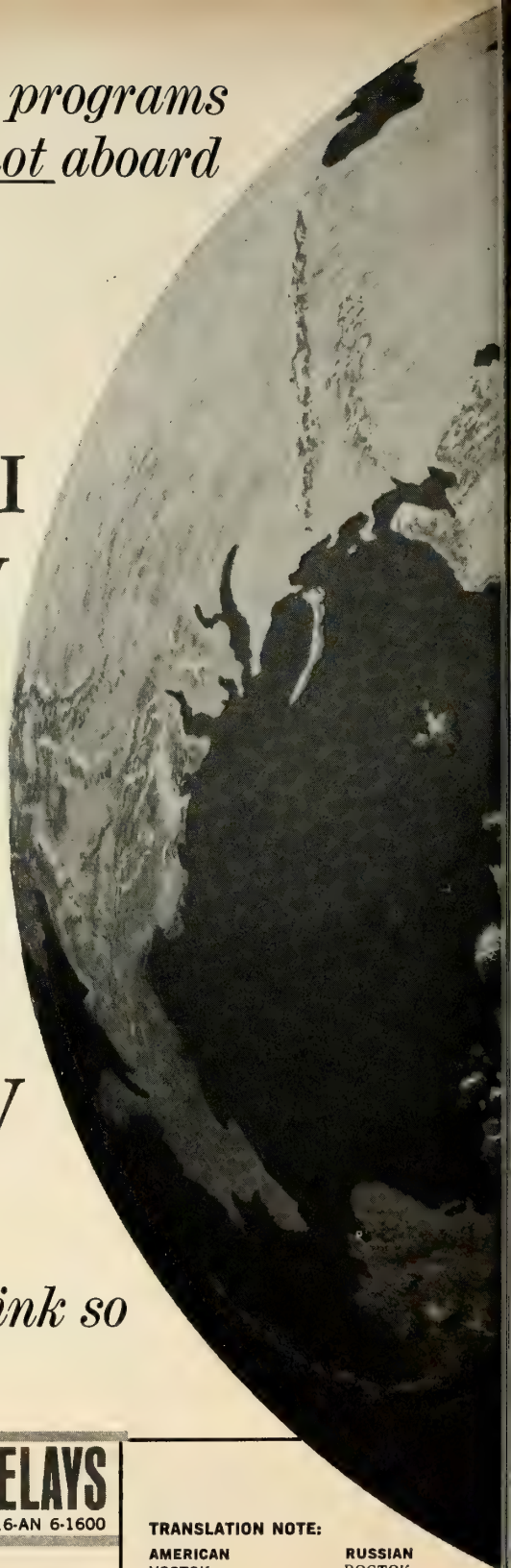

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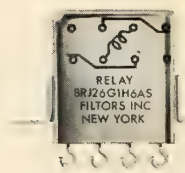

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LUNIK	ЛУНИК
COSMOS	КОСМОС
ZOND	ЗОНД
VOSKHOD	ВОСХОД
SPUTNIK	СПУТНИК
ELECTRON	ЭЛЕКТРОН

New Silicone Rubber Foams Detailed

Novel pair of tough, room-temperature-vulcanizing substances developed by GE for damping, insulation and ablation uses

by John F. Judge

TWO NEW silicone foam-rubber formulations are in commercial production at General Electric's Silicone Products Dept., Waterford, N.Y.

The first, designated RTV-7, is a room-temperature-vulcanizing liquid-silicone rubber which cures to a flexible foam. Its density can be changed by blending with standard liquid-silicone rubber compounds.

The second is a flame-proof silicone rubber that foams and cures in place to form a lightweight thermal blanket. Marketed under the designation RTV-757, the material is a thixotropic paste which cures to a rugged sponge in minutes after heat activation.

Both rubbers were introduced at the National Symposium of the Society of Materials and Process Engineers (SAMPE) in San Francisco last week.

The RTV-7 compound can be foamed on the spot to provide mechanical support, shock and vibration damping and for uses as lightweight electrical insulation and low-density thermal insulation.

The material is supplied as an uncatalyzed black base compound of 7,000 to 9,000 centistoke viscosity. Thorough mixing with a curing agent initiates the curing and expanding action.

The expanded compound is similar to other silicone rubbers in its flexibility at low temperatures and its resistance to high temperatures. The range revealed by GE is —65° to 600°F.

The curing and foaming process can take place in a variety of environments —even in water, where the RTV-7 generates an independent atmosphere and is capable of displacing water to buoy sunken objects.

● **Engineered silicones**—The blending aspects of the material were detailed at the SAMPE meeting by chemist Michael B. Sullivan of the Silicones Dept. The blending procedures are modification steps to adjust the compound to the particular needs of a user.

Sullivan says the greatest area of variation is in the addition of selected fillers to the compound. Increased density can be achieved by compounding the base material with ground quartz or diatomaceous earth. Inclusion of fumed silicas reinforces the silicone rubber matrix and increases the strength of the rubber, says Sullivan.

But fumed silicas have a deleterious effect on the shelf life of the base compound. Sullivan says any modification which uses strongly acidic or basic materials can only be handled by the user if he is aware of its limitations.

Such variations necessitate prompt use of the modified material before its chemical nature can be appreciably altered. Sullivan also warned fabricators that many changes are concomitant—the addition of a high-density filler will increase both density and compression deflection properties.

The second area of ready modifications described by Sullivan is the combination of the base compound with other RTV silicone-rubber materials. Compression and deflection characteristics can be closely controlled as well as altered.

AN RTV-757-COATED paperboard container covered this flower during a 60-second application of the 5,000°F flame source. Temperature inside the container went from 71° to 84°F in this demonstration of one of GE's new foam materials.

The RTV blend approach affects bulk properties such as strength. While a definite increase in tensile strength is observed in these blends, Sullivan says the results can be misleading. The addition of a standard RTV increases the density by decreasing the blowing agent-to-polymer ratio. This increase in density implies that the cell walls themselves have increased in size.

Bulk foam appears stronger because the cross-sectional area of elastomer is greater.

● **Blend to environment**—Elevated temperature performance can be attained by blending the base compound with RTV's containing heat-aging additives and stabilizers. These stabilizers impair the polymer breakdown caused by reversion and prevent embrittlement of the cured foam.

Samples of such mixtures have passed heat-aging tests at 500°F.

The RTV-757 compound is expected to find use in any application where flame and heat protection is needed. Specimens 0.5 by 6 by 0.75 in. suspended vertically in a 2.5-in. glass chimney and subjected to a 2,000°F gas flame for 20 seconds did not ignite or otherwise support combustion.

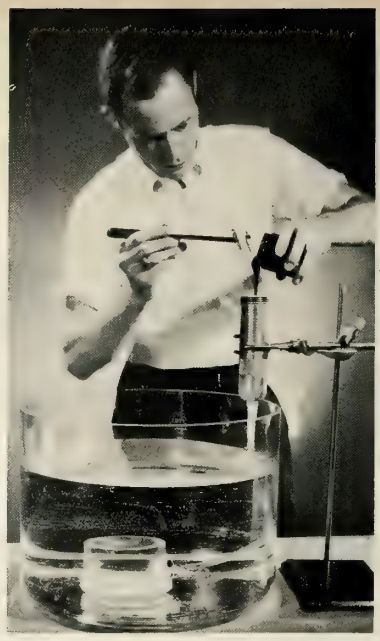
No material cracking or loss of flexibility was observed following the test. Under unconfined conditions, specimens bonded to metal panels and exposed to the same temperature/flame source at a 45° angle for 15 minutes failed to propagate a flame.

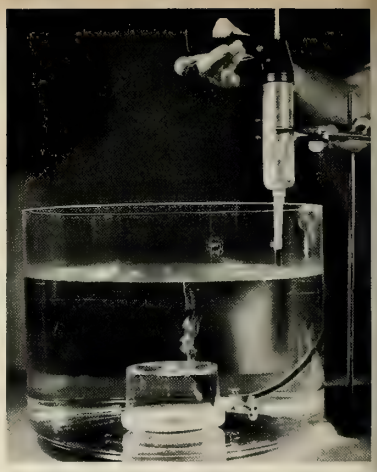
RTV-757 has a tensile strength of 250 psi in its cured form—much higher than other silicone rubber foams. The material is a methyl phenyl silicone rubber and maintains a low-temperature flexibility below —150°F.

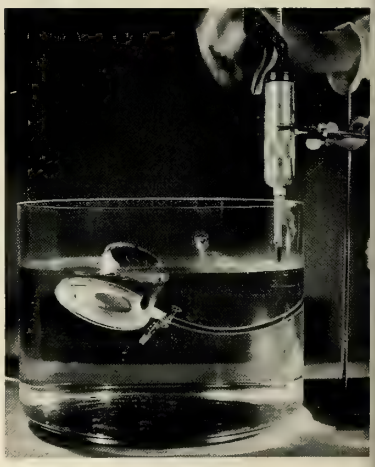
RTV-757 forms a high-strength foamed ablative shield which develops a tough surface crust under direct exposure to a +5,000°F oxyacetylene torch at durations greater than 60 seconds. The ablative crust maintains internal foam integrity, thermal insulation and the nonflammable characteristics of the material.

GE engineers caution that since the actual ablative performance of any material is dependent upon each specific environment, with design limitations controlled by the programmed application or vehicle, actual material evaluation is recommended to establish the full limits of RTV-757's ablative performance.

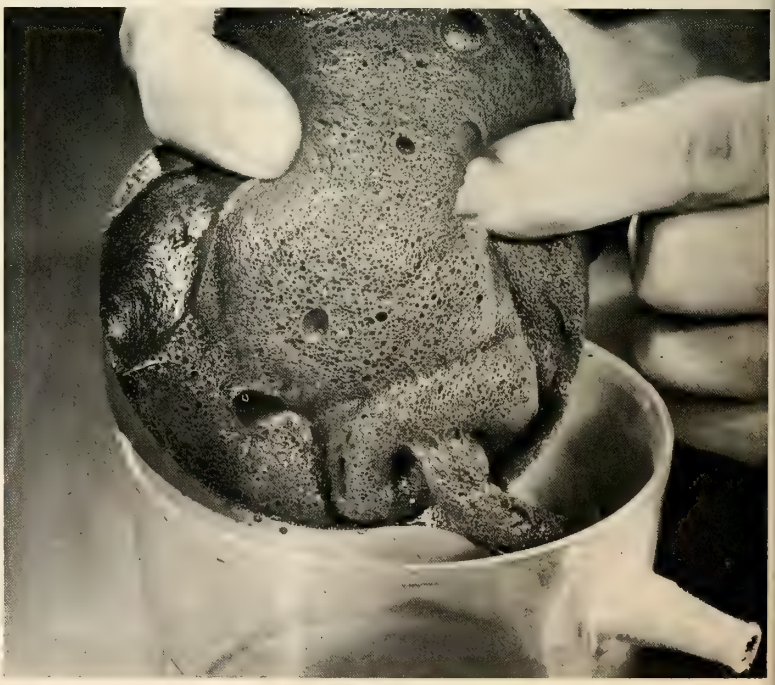
The foam rubber compound will cure in contact with most substrates but certain materials such as butyl and chlorinated rubber, sulfur-containing compounds and amines used as catalysts can cause inhibition of cure. For this reason, a primer coat—designated SS-4120—should be applied prior to bonding the RTV-757. ■







THE ABILITY of the RTV-7 to cure underwater and supply buoyance is illustrated here. The liquid rubber is forced through the hose to the water-filled vessel, expands and floats the vessel to the surface. The water is forced from the vessel by the rubber's expansion. The fully expanded foam is shown below after it has been removed from the water tank.



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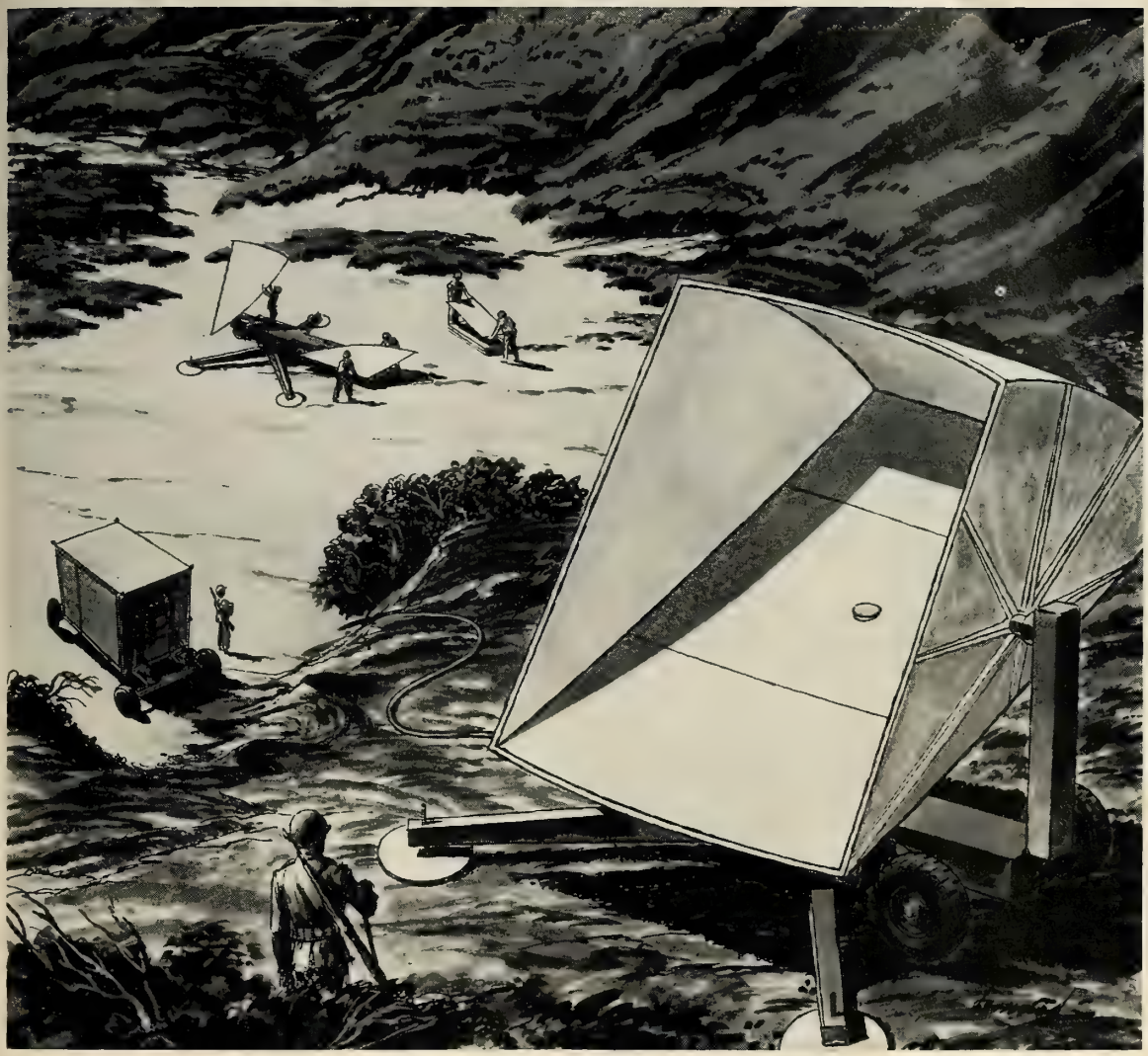

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AF Pilots To Simulate Apollo Flight

Martin studies for NASA put unprecedented emphasis on pilot reliability; plans include elaborate exercise program to maintain physical fitness

by Heather M. David

BALTIMORE—Preliminary training of three Air Force Aerospace Research School pilots is under way at the Martin Co. in preparation for a seven-day *Apollo* lunar-landing mission simulation designed to get data on exact limits of pilot performance.

The test, under the direction of Martin's Dr. Milton A. Grodsky and NASA's Dr. Heber G. Moore, is part of a series of three such simulations to be accomplished in the next 19 weeks under a new contract just awarded Martin by NASA. They will duplicate lunar-landing mission simulations run by Martin for NASA under previous contracts.

Unique in the Martin studies is the fact that prime emphasis is on pilot reliability rather than performance of equipment. Grodsky points out that while billions of dollars are spent in checking out reliability of spaceflight hardware, relatively little is done to assess the probable performance of the man.

The studies will provide NASA with a data bank on which to base estimates of pilot reliability for *Apollo* and make future mission decisions.

● **Preliminary conclusions**—Results of several such studies in the past indicate that there is no statistically significant degradation of performance reliability except during some mid-course-correction switching modes.

These tests debunked the theory that pilot performance would degrade gradually as the mission wore on. Instead, they indicated that during the major dynamic phases of the mission—such as translunar insertion and lunar insertion and landing—the pilots were "up" for the tasks and performed pretty much as expected. However, during the mid-course corrections period both to and from the Moon, during which the workload was not as high and was more routine in nature, errors tend to appear.

Another conclusion drawn, Grodsky told M/R, is that the selection process for astronauts—from experienced test pilots—is a good one. This group, he said, has been found to be physically, emotionally, and intellectually superior. Their performance has been very good; although it is not perfect, it ranges between 0.9 to 1.0, he said.

For purposes of the study, the pilots were assumed to be the primary mode of control rather than backup, in contrast with plans for the actual *Apollo* mission. In addition, the seven-day Martin missions are only conceptualizations of the *Apollo* mission; hence they will remain standard in spite of the changing nature of the *Apollo* program. The three seven-day landing missions previously run and the upcoming trio are identical, to provide significant numbers on the same tasks.

● **Training period**—The five-week pre-mission training period now being conducted at Martin will familiarize the

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crack AF pilots with all tasks they will be expected to perform and prepare them for all contingencies they may have to face. Baseline data also are gathered during this period for comparison with mission simulation data.

Heavy emphasis is placed upon physical conditioning of the men. Grodsky told M/R this was because of experience in early studies in which the subjects complained of minor aches and pains from the unaccustomed confinement and inactivity, and their motivation appeared to be affected.

Thus, Martin called in a real expert —trainer Dr. Ed Block of the Baltimore Colts professional football team—to develop a series of exercises to prepare the pilots for the sedentary existence they will lead during the seven-day mission. A special gymnasium has been built at Martin for the pilots' use during the five weeks' pre-mission period.

Grodsky points out that building up the crew's condition, together with a regimen of isometric exercise during the mission, assures that there will be no significant degradation in their physical condition.

● **Testing procedure**—The simulation will be conducted in the million-dollar Martin Lunar Mission simulator, a high-ceilinged, soundproof 1,500-sq.-ft. room.

Within the chamber, which is painted a dull blue-black to simulate empty space, are a full-scale mockup of the *Apollo* Command Module and Lunar Excursion Module (LEM). A mission control and data collection facility are in adjoining chambers. Some 550 channels are available.

Realistic flight plans are kept throughout the seven-day "trip," including communications, medical monitoring (blood pressure, pulse and temperature during each orbit) in accordance with opportunities as they would occur in the *Apollo* communications and tracking network. This will include simulation of the communications delay from the Moon. A tape recorder keeps a record for later study.

To keep the variable of physical deconditioning out of the picture, isometric exercises using a bar and chain with a calibrated pull rate will be performed six times each day, for a total of 30 minutes in 24 hours.

The Command Module simulator is a fixed-base wooden mockup with realistic cockpit and control devices. During the ascent phase, the pilots control the vehicle's attitude, initiation, and cutoff of the Service Propulsion System thrusting, with aid of the *Apollo* Guidance Computer for necessary data. Sound effects will portray the noise of the launch vehicle stages, to carry out the realism of the simulation.

The *Apollo* simulation vehicle also contains fairly realistic replicas of sleeping, off-duty and navigation task areas. Three TV monitor cameras provide closed-circuit TV of the actions of the crew to the control room. During the forthcoming test, the Air Force will provide its own communicators from the Aerospace Research Pilots School.

The LEM simulator is mounted in such a manner that it can swing around for the transposition maneuver. The module is mounted on a three-axis gimbal system which allows travels of $\pm$ 40° in pitch or roll, and $\pm$ 180° in yaw. Crew area, control panels, windows, forward hatch and the like duplicate the LEM vehicle as of November, 1963, although some changes have been made in the actual craft since then.

Two projectors provide realistic displays for different portions of the mission. One, mounted near the ceiling of the room, projects a starfield with some 2,300 major stars and constellations for navigation fixes. The whole scene appears on a 24-ft.-dia. spherical screen which envelopes the LEM and *Apollo* simulators in such a way that the out-the-window view is duplicated. The scene moves with simulated changes in the vehicle's attitude.

The screen also is used for projection of a simulated lunar surface for the landing maneuver. After liftoff from the Moon, a projector flashes on a blinking light simulating the approach to the Command Module. This light increases in size as the LEM approaches, and at the proper distance the screen is divided and wheeled away.

As the screen is removed, a translator, simulating the Command Module, is revealed above the pilots, with a beacon of the same size last seen on the screen. Six degrees of freedom are represented in the rendezvous and docking maneuver.

However, the first three are provided in the LEM itself, with pitch, roll and yaw controllable by the pilot with one hand. With his other hand, the pilot moves the translator, which has fore-aft, vertical and lateral travel modes. Although in actual practice only the LEM would move, the simulation is such that the same tasks would be performed by the pilot even if he were moving all six degrees in one vehicle instead of two.

The Air Force will also provide biomedical support for the experiment, and will take the opportunity to test its new liquid space diet.

First seven-day run will begin June 21. Air Force crews for the second and third runs will report July 6 and August 16 for five-week pretraining and one-week missions. ■

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MISSILES AND ROCKETS is offering a unique opportunity to get extra impact at low cost before and during the AIAA Show. Advertisers placing a one-page or larger ad in the AIAA Section of MISSILES AND ROCKETS July 19, 1965 issue will automatically earn a 25% discount on advertising run in MISSILE/SPACE DAILY.

Your advertising in MISSILES AND ROCKETS pre-show issue and MISSILE/SPACE DAILY will reach over 61,000* of the nation's leading Missile/Space/Military/Aviation decision makers—the people responsible for making the important buying decisions.

**45,000 regular paid circulation in MISSILES AND ROCKETS, 16,000 in MISSILE/SPACE DAILY.*

MISSILE/SPACE DAILY

PUBLISHING DATES: JULY 26, 27, 28, 29

ADVERTISING CLOSES: JULY 12

MISSILES AND ROCKETS

PUBLISHING DATE: JULY 19, 1965

ADVERTISING CLOSES: JULY 6, 1965

For more information on advertising rates and mechanical requirements, see your local MISSILES AND ROCKETS advertising representative.

AMERICAN AVIATION PUBLICATIONS, 1001 VERMONT AVENUE, N.W., WASHINGTON, D.C. 20005

AWARDS

AIR FORCE

$2,666,840—**The Bendix Corp.,** Detroit, initial funding on $22 million contract for work on space tracking radar equipment at Towson, Md., and Elgin AFB, Fla.

$2,428,508—**Hycon Manufacturing Co.,** Monrovia, Calif., for work on cameras.

$1,199,052—**General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., Buffalo, N.Y., for work on ground electronics system for *Minuteman* missiles.

$1,110,314—**International Telephone and Telegraph Corp.,** Fort Wayne, Ind., to make electronic equipment.

$750,000—**General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., Buffalo, N.Y., initial funding on multi-million dollar contract for installation of underground cable communication system to link new *Minuteman* sites in Montana.

$190,277—**Radio Corp. of America,** Missile and Surface Radar Div., Moorestown, N.J., for a classified program.

$175,000—**Radio Corp. of America,** Missile and Surface Radar Div., Moorestown, N.J., for the BMEWS program.

$25,000—**Radio Corp. of America,** Missile and Surface Radar Div., Moorestown, N.J., for a classified program.

ARMY

$1,296,000—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for adaptation of the M-60 tank for launch of *Shillelagh* missiles.

$565,692—**Aerojet-General Corp.,** Solid Rocket Plant, Sacramento, Calif., for evaluation of high-energy propellant ingredients.

$300,000—**Thiokol Chemical Corp.,** Elkton, Md., for evaluation of high-energy fuels and oxidizers.

$45,000—**Radio Corp. of America,** Astro-Electronics Div., Hightstown, N.J., for a classified study.

NAVY

$13,500,000—**Sangamo Electric Co.,** Springfield, Ill., for a sonar improvement kit.

ENGINEERS

Investigate opportunities with a dynamic, fast-growing reliability and systems enginering organization.

Expanding activities at our Huntsville Division have created a need for the following personnel:

Systems Engineer BS/MS, EE, ME	Experience in preliminary design studies of aerospace systems; evaluating feasibility of alternate approaches; experience with total system requirements including propulsion, telemetry, guidance control, configuration management, data system analysis.
Mechanical Engineer BSME	Experience in rocket propulsion systems, testing facilities, propellant supply systems, test program planning, project development.
Electrical Engineer BSEE	Experience in electronic circuits, reliability analysis, telemetry and guidance.
Statistician BS/MS, Statistics	Familiarity with basic reliability data —failure rates and failure reporting; design of experiments; computer experience.

Contact P. D. Sevec / Personnel Manager / ARINC Research Corporation / 1700 K Street, N.W. / Washington, D.C. 20006—or—E. J. Kennedy / ARINC Research Corporation / Huntsville Division / 2400 Bob Wallace Avenue / Huntsville, Alabama 35805

ARINC
RESEARCH CORPORATION

$11,922,200—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for components for *Polaris A-3* missile.

$2,472,571—**Planning Research Corp.,** Los Angeles, for additional study work on data processing systems.

$2,348,783—**Westinghouse Electric Corp.,** Sunnyvale, Calif., to manufacture generators for use with *Polaris* missile systems.

$1,187,122—**Magnavox Co.,** Fort Wayne, Ind., for construction of radio-beam sonobuoys.

$1,020,517—**Western Gear Corp.,** Lynwood, Calif., for sonar equipment.

$658,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., for a classified program.

$540,000—**American Electronic Laboratories, Inc.,** AEL Products, Inc., Colmar, Pa., for the production of azimuth indicators.

$43,274—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., for MICS program.

NASA

$1,600,000—**Aero Spacelines, Inc.,** Van Nuys, Calif., for transporting *Saturn* upper stages and large rocket components.

$784,600—**Mechling Barge Lines, Inc.,** Joliet, Ill., for towing three *Saturn* barges.

$130,000—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., to study radiation in the gas cap in front of a vehicle entering the Mars atmosphere.

$127,655—**Radio Corp. of America,** Astro-Electronics Div., Hightstown, N.J., contract increase for AVCS.

$100,000—**General Applied Science Laboratories, Inc.,** Westbury, N.Y., for production of a five-channel transient analytical system to be used in checking out portions of the *Saturn* rocket's electrical and electronic system.

$100,000—**Radio Corp. of America,** Astro-Electronics Div., Hightstown, N.J., contract increase for APT tape recorder.

$71,000—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., to develop computer programs for Mars-Venus atmospheric entry studies.

INDUSTRY

$52,675,000—**Raytheon Co.,** Lexington, Mass, from **General Motors Corp.,** A.C. Spark Plug Div., Milwaukee, remainder of $76,275,000 contract to produce on-board digital computers for the *Apollo* manned lunar mission.

$3,000,000—**Dynalection Corp.,** Washington, D.C., from **Bell Aerospace Corp.,** Bell Aerosystems Co, Buffalo, N.Y., for the continued development, operation and maintenance of the U.S. Army Electronic Proving Grounds' Systems Test Facility in Nevada.

$2,137,227—**Avco Corp.,** Electronics Div., Cincinnati, Ohio, from **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for development of a digital command assembly for LEM; from **The Boeing Co,** Seattle, for production of telemetry equipment for *Saturn V* first stage; and from the **U.S. Army** for supplying radio command guidance destruct receivers for missiles tested at White Sands Missile Range, N.M.

$974,144—**Ralph Engelstad Construction Co., Inc.,** Las Vegas, from **Catalytic Construction Co.,** Mercury, Nev., for the erection of a technical service shops building and maintenance shops building in the Central Support Area of the Nuclear Rocket Development Station, Nev.

$148,114—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., from **Electro-Mechanical Research, Inc.,** Sarasota, Fla., for *Gemini* magnet tape recorder/reproducer.

$114,000—**Radio Corp. of America,** Astro-Electronics Div., Hightstown, N.J., from **North American Aviation, Inc.,** El Segundo, Calif., for *Apollo* television.

$100,000—**Whittaker Corp.,** Controls and Guidance Div., Chatsworth, Calif., from **Aerojet-General Corp.,** El Monte, Calif., for course control gyroscopes for Navy Mark 46 torpedo.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Fort Monmouth Procurement Division
Procurement and Production Directorate
U.S. Army Electronics Command
Fort Monmouth, N.J. 07703

An award is being made to Philco Corp. to continue research work in the field of satellite communications. No other offers will be considered.

John F. Kennedy Space Center
Cocoa Beach
Florida 32931

RFP A-17-5, due June 23, 1965, for a study to determine the total requirements which would be imposed on the presently programmed *Apollo* pre-flight checkout and launch operations at Cape Kennedy. When requesting bid sets, provide information as to whether your organization is a large or small business.

Circle No. 34 on Subscriber Service Card

Headquarters, Ballistic Systems Division
Norton AFB, California 92409

Negotiations are being conducted for an eight-month study to provide technical consultant services for engineering to evaluate the *Titan II* intersite radio communications system. RFP not available; for information only.

U. S. Army Missile Command
Procurement and Production Directorate
Procurement Operations
Systems Contracts Div. A
Negotiation Branch 2
Attn: AMSMI-IWB
Redstone Arsenal, Alabama 35809

Those interested in subcontracting opportunities with Philco Corp.'s recently awarded $2-million contract to adapt the M-60 vehicle turret for the *Shillelagh* missile system should contact Philco Corp. directly.

NASA Manned Spacecraft Center
General Procurement Branch
2102 Webster-Seabrook Road
Houston, Texas

RFP BG721-18-5-1003P, available until June 7, 1965, for the design, development, fabrication and flight qualification of an ergometer assembly. RFP's issued until supply is exhausted.

Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Negotiations will be conducted with Hughes Research Laboratories for modification of a micro-thrust measuring stand. For information only; RFP not available.

Officer in Charge
U.S. Navy Purchasing Office
929 S. Broadway, Metropolitan Station
P. O. Box 5090
Los Angeles, California 90055

Selected source procurement from General Electric Co., for continued development of a miniature UHF telemetry transmitter. For information only; RFP not available.

NASA Manned Spacecraft Center
Gemini Flight Support Procurement Center
Houston, Texas 77058

NASA is negotiating with Aerojet-General Corp. for a service propulsion system restart capability study. For information only; RFP not available.

Air Force Flight Test Center
Directorate of Procurement
Edwards AFB, California
Attn: FTMKB

Research and development sources are being sought for packaged system components for a liquid rocket propulsion system storability demonstration program.

Air Force Flight Test Center
Directorate of Procurement
Edwards AFB, California
Attn: FTMKB

Research and development sources are sought to design, fabricate, test and deliver a handling and transporter system for 156-in.-dia. solid rocket segments and monolithic motors.

Air Force Flight Test Center
Directorate of Procurement
Edwards AFB, California
Attn: FTMKB

Research and development sources are sought to design, fabricate and qualify test devices and associated equipment for in-space evaluation of propellant orientation and venting devices.

Air Force Special Weapons Center
Procurement Directorate
Attn: SWMKB
Kirtland AFB, New Mexico 87117

Continuation of effort for incorporation of engineering changes of RVU-11/E. This is a sole source solicitation to NTW Missile Engineering, Inc. as a follow-on for work previously performed. This notice is issued for the benefit of prospective subcontractors with appropriate security clearance which should make direct contact with the above firm for subcontracting opportunities.

U.S. Army Missile Command
Procurement and Production Directorate
Procurement Operations
Systems Contracts Div. A
Negotiation Branch 2
Attn: AMSMI-IWB
Redstone Arsenal, Alabama 35809

A $600,000 contract has been awarded to General Electric Co. for a synthetic radar research program. Those interested in subcontracting opportunities should make direct contact with GE.

Being here is half the fun.

The other half: a satisfying career.

It's Spring in New England. The golfers, gardeners and fishermen are out. The land holds promise of long, sparkling days . . . of barbecues, swimming, boating and picnics in the rolling green Connecticut countryside. Your family will enjoy *every* season of New England. And, equally important, you'll be building a career with a dynamic, diversified engineering company that offers state-of-the-art projects in Life Support Systems, Ground Support Equipment, and a great variety of controls and precision products for the aerospace field.

PRELIMINARY DESIGN-ADVANCED PLANNING FOR 1) SPACE LIFE SUPPORT SYSTEMS 2) ATTITUDE CONTROL AND REACTION CONTROL SYSTEMS FOR SECONDARY PROPULSION SYSTEMS. Will conduct preliminary design and program studies, prepare and present new product proposals in one of the systems indicated above. Requires knowledge of combustion/propulsion, or thermodynamics, heat transfer and/or environmental system analysis. Must be able to direct and coordinate work of design and project support technical personnel.

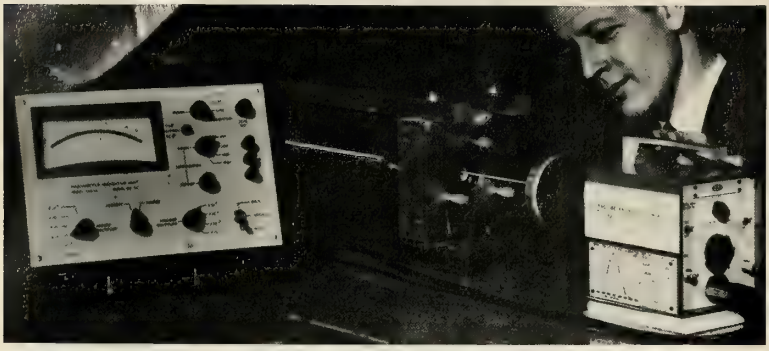
ADVANCED DEVELOPMENT ENGINEERS to conduct studies in field of space life support systems and coordinate technical efforts of others preparing technical sales proposals; assist in planning research and feasibility programs. Interpret and translate customer requirements into practical design programs. Requires experience in one or more: space life support systems or thermodynamics/heat transfer or mechanical/hydraulic/pneumatic systems. Must be able to make technical presentations to management and customers.

SR. EXPERIMENTAL ENGINEERS, ME or AE. Should have experience in R&D testing of control systems involving engineering mechanics, fluid mechanics and/or servomechanisms. Assignments will be in one of our product engineering groups (i.e. hydraulics, propulsion, environmental controls) planning, conducting and evaluating product development programs (missile and aircraft control equipment).

MECHANICAL ENGINEER, Ground Support Equipment, to conduct product design and development programs from proposal to final production stage. Will be responsible for producing a wide variety of mechanical equipment involving hydraulics, pneumatics and cryogenics at a minimum cost. Products would include mobile or stationary test facilities and equipment applicable to the aircraft and aerospace industries.

GET THE DETAILS on our many fine benefits including generous relocation allowance and an outstanding graduate study program. Please forward your resume, including present salary, to Mr. H. M. Wakeman, Personnel Department, Hamilton Standard, Windsor Locks, Connecticut. We are an equal opportunity employer.

Hamilton Standard
DIVISION OF UNITED AIRCRAFT CORPORATION
UA



New Product of the Week:
Narrow Beam Adapter/Laser Attenuator

A narrow beam adapter/laser attenuator for use with its 580 radiometer system is being marketed by Edgerton, Germeshausen & Grier, Inc.

With the accessory, the radiometer detector head can directly monitor output of a solid, gas or diode laser for measurement of energy, power and pulse shape characteristics. The attenuator is calibrated as to its absolute attenuation as a function of wavelength.

With the attenuator, the system's indicator unit provides direct meter readout of average power of steady state light and integrated energy of pulsed light. When used with an external oscilloscope, measurement can be made of peak power and wave shape of pulses having rise times down to 1 nanosecond.

Circle No. 151 on Subscriber Service Card

FLEXIBLE CIRCUITRY

BRAZED-BONDED HARDWARE
TEFLON INSULATION
100% REPAIRABILITY

The concept of electronic packaging with flexible circuitry has entered a new dimension through the development of the brazed-in-place tubelet by E/M. The tubelet as furnished in E/M's flexible circuitry or multi-layer hardboard is brazed to its internal termination at a temperature in excess of 1300°F. The soldering of components is made to the tubelet. Results?—no pad lifting and extremely reliable 360° solder joints. Want to remove a component already soldered to E/M circuitry? Go ahead! Remember, you are soldering to the brazed-in-place tubelet—not directly to a 2-3 mil thin pad. Results? Repairability in your package without sacrificing a complete circuit.

Could you use a multi-layer hardboard that has continuous, integrated flat flexible leads emanating from any or all directions? Try the E/M combination of flexible and hardboard circuitry. Again, all terminations/hardware employ the brazed-in-place tubelet.

For further information, please write to:

Electro-Mechanisms, Inc.
53 Osgood Street
Methuen, Mass. 01844
Attn: Sales Manager

E/M ELECTRO-MECHANISMS, INC.

Circle No. 35 on Subscriber Service Card

Liquid-Metal Pump

A solid-state pump that can provide flow to high-temperature liquid metals is being produced by Atomics International, a division of North American Aviation, Inc.

The thermoelectromagnetic pump consists of a direct-current liquid metal conduction-type pump powered by an integral thermoelectric "direct-conversion" generator.

The conduction pump portion of the unit consists of electrodes mounted on opposite sides of the channel through which the liquid is pumped. Permanent magnets create a magnetic field perpendicular to the electric current passing through the liquid metal. The resultant pumping force on the liquid metal is proportional to the electrical current, magnetic field and width of the fluid channel.

The unit measures 1 ft. long and weigh 45 lbs. It can pump at temperatures up to 1,300°F and has a design lifetime of 10,000 hours.

Circle No. 152 on Subscriber Service Card

Solid-State Inverter

ITI Electronics, Inc., is marketing a solid-state inverter with an input capability of 245v dc ±15%.

The Model HVI-300 provides outputs of 117v ac at 50 va, 250 va and 500 va. The control circuit provides input transient voltage capability of 600v dc, line-to-line. This permits use of Thyrite-type protective devices to handle large transient voltage surges, the firm says. Conversion is accomplished at efficiencies of 70 to 80%. The device is designed to operate continuously at ambient temperatures from −10° to 50°C.

Circle No. 153 on Subscriber Service Card

Automatic Weld Station

A complete weld station that offers pushbutton selection of energy and force settings is being marketed by Weldmatic Div./Unitek.

The modular automatic weld station provides instant selection of six repeatable weld conditions. The stations consists of a multi-pulse power supply (mounted under the workbench), a miniature welding head, a remote program selector and a footpedal actuator.

Energy is continuously adjustable from 0.7 to 100 watt-seconds; force continuously adjusts from 1 to 12 lbs. Standard (0.0021 sec.), normal (0.0035 sec.), and long (0.0078 sec.) pulse durations are available. Welding repetition rate is 150 welds/minute at 0.5 w-s, or 80 welds/minute at 100 w-s. A dual weld head interconnector accessory permits use of two welding heads.

Circle No. 154 on Subscriber Service Card

Voltage Regulators

A series of line voltage regulators from 500 va to 5 kva is available from Microdot Magnetics, Inc.

The units can be used in three-phase wye or delta configurations for balanced or unbalanced loads. According to developers, reliability is increased by the isolation of all semiconductors from power-handling circuits to avoid component failure. Actual load current and supply voltage are handled by magnetic currents.

Input voltage range is 103 to 127v with output of 115v; output range is 100 to 120v. Regulation is ± 0.1 rms. Response to line and load charges is 30 to 75 ms. Input frequency is 57 to 80 cps.

Circle No. 155 on Subscriber Service Card

Linear Accelerometer

Control Data Corp.'s Cedar Engineering Div. has available a linear accelerometer featuring a sensitivity and hysteresis of 0.03 g.

Linearity of the Type G-6162 is 1% with a range of 0 to 5.5 g. Damping ratio is 0.5 to 0.7. Input is 26v, 400 cycles. Output is 3v per g, 400 cycles.

The unit has a useful temperature range of $-55°$ to 71°C. It exceeds requirements of MIL-T-27330. Weight is 30 oz.

Circle No. 156 on Subscriber Service Card

Flashtube

A high-energy flashtube, designed for pulsed laser applications, has been developed by Xenon, Inc.

The Model C6-202 has a 2,000-joules/pulse input capability. Spectral characteristics approximate natural sunlight, covering the visible range and extending into the ultraviolet and infrared. The device has a lifetime of 1,500 shots in free air at 2,000 joules/pulse when fired at 2 kv with a 300-microhenry series choke. Concentric arc electrodes localize the arc in the center of the quartz envelope and guard against quartz devitrification at electrode contacts.

Circle No. 157 on Subscriber Service Card

Electron Beam System

An electron beam system, designed to investigate lasering action of solid-state materials, has been developed by Microperv, Inc.

The system consists of an electron beam column with focusing and deflection capabilities; high-vacuum valve; ion pump; ion pump power supply; and a high-voltage pulse power supply.

The beam column operates from 0-50 kv and produces peak currents in excess of 50 ma. Focussed spot sizes at the output are 0.025 in. and smaller. The electron gun utilizes an impregnated cathode and mesh grid requiring a positive pulse. For increased cathode life, the gun region is isolated from the work chamber by a valve and is maintained at 10^{-7} torr when the work chamber is open to the atmosphere.

Circle No. 158 on Subscriber Service Card

new literature

VACUUM COMPONENTS CHART—A fold-out reference chart on vacuum components is available from Equipment Div., National Research Corp. Components are listed so that compatible products may be selected to assemble a complete vacuum system. Information includes a schematic diagram of a typical system. Free of charge.

Circle No. 159 on Subscriber Service Card

RESOURCES DIRECTORY—A Directory of Information Resources in the United States, covering the physical sciences, biological sciences and engineering, has been prepared by the National Referral Center for Science and Technology, Library of Congress. The 356-page volume lists a variety of organizations and institutions capable of meeting specific information needs. Included are libraries, information centers, professional societies, universities, government agencies and industrial firms. Paperbound, $2.25.

Circle No. 160 on Subscriber Service Card

SPACE MATERIALS HANDBOOK—A handbook on effects of space environments on materials, first prepared as an Air Force-sponsored report by scientists at Lockheed Missiles & Space Co., is now available in published form. The reference work provides a collection and interpretation of effects on materials. It is divided into four parts: the space environment; effect of the environment on materials; materials in space (materials applications); and biological interaction of materials. Available from Addison-Wesley Publishing Co.; price, $15.00.

Circle No. 161 on Subscriber Service Card

PRECIOUS METALS BULLETIN—A 12-page bulletin entitled "Precious Metals and High Purity Nickel as used in Temperature Measurements" is available without charge from Sigmund Cohn Corp., Dept. P.M. The two-color publication provides information on such subjects as: Platinum and Platinum-Rhodium Thermocouple Wire; Iridium vs. Iridium-Rhodium; Resistance Thermometer Elements, and many tables, including: thermal EMF values of thermocouples; and weights of platinum wire at various diameters.

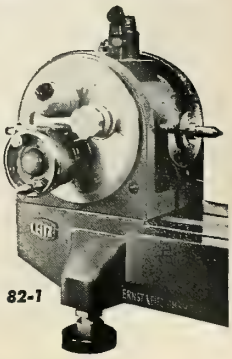
Circle No. 162 on Subscriber Service Card

FOR ULTRA PRECISION IN SPACE

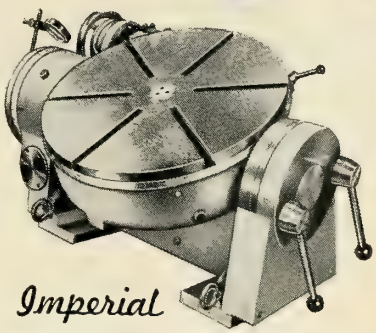
Leitz

OPTICAL MASTER DIVIDING HEAD

Working accuracy ±1second of arc through double microscopic pick-up to compensate for errors from run-out.



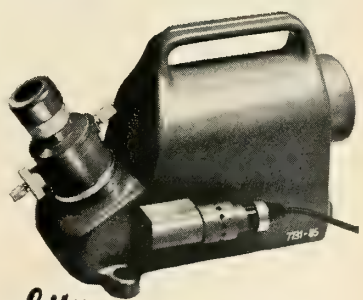
Request catalog 82-1



Imperial

ROTARY AND INCLINABLE TABLES

High Precision types ± 10 seconds accuracy
Ultra Precision types ± 5 seconds accuracy
Reading in 1 second
Dividing errors in worm and wheel compensated by circumferential correction cam. *Request catalog 7282*



Leitz

AUTO-COLLIMATOR AND POLYGONS

A new concept in compactness and convenience of operation. Exceptionally long range of measuring scale up to 30 minutes for interpolation in 1/10 second. *Request catalog 85-3*

OPTO-METRIC TOOLS, INC.
137 MR VARICK STREET,
NEW YORK 13, N. Y.

Circle No. 29 on Subscriber Service Card

Sterling Presents —

A NEW CONCEPT IN THE ELASTOMER FIELD!

1. Molded and hand lay-up rubber insulation for Rocket Motor Cases.
2. Precision rubber molded and extruded items.
3. Full laboratory facilities for development of elastomeric compounds, testing and certification.

STERLING LABORATORY & DEVELOPMENT CO.

U.S. Route No. 1—Box 97
Monmouth Junction, N.J. 08852
Phone 452-2680—Area Code 609

Circle No. 30 on Subscriber Service Card

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Six Weeks Is Required To Change Your Magazine Address

A regulation of the Post Office requires that you pay extra postage if copies of

MISSILES AND ROCKETS

are forwarded to you at your new address. Copies will not be forwarded free and we cannot replace lost copies. To insure delivery at your new address please notify us at least six weeks in advance of your moving. Send us your old and new address, and, if possible, the address label from your last issue . . . include your postal ZIP number. Thank you.

Write to:

Missiles and Rockets
Circulation Department
1001 Vermont Ave., N.W.
Washington, D.C. 20005

names in the news

SPANGLE

ROSENBLOOM

CARNE

ADAMS

Clarence W. Spangle: Named to the new post of vice president and general manager of Honeywell Inc.'s electronic data processing division. He was formerly managing director of Honeywell Controls, Ltd., London.

Dr. Arnold Rosenbloom: Appointed director of Houston Operations and director of Apollo spacecraft systems analysis program with TRW Space Technology Laboratories. He will be responsible for providing facilities and services to STL personnel at NASA's Manned Spacecraft Center.

Dr. E. Bryan Carne: Named director of engineering for Ling-Temco-Vought's LTV Electrosystems, Inc.

Clark G. Adams: Will be installed as president of the National Contract Management Assn. early next month. He is director of contracts and pricing at North American Aviation, Inc.

George N. Butzow: Named to the newly created position of vice president and sales manager of the MTS Division of Research, Inc.

Henry P. Lemaire: Appointed manager, memory products engineering, for Radio Corp. of America's memory products operations department.

Samuel B. Sherwin: Appointed vice president of Gulton Industries, Inc. He joined the company a year ago as executive assistant to Dr. Leslie K. Gulton, president.

Dr. Donal B. Duncan: Assumed the responsibilities as acting director of the Applied Research Laboratories of Philco Corp.'s Aeronutronic Div. He is also general manager of the division.

William G. Reynolds: Selected to receive the American Society for Metals' Medal for the Advancement of Research. Executive vice president in charge of research and development for Reynolds Metals Co., he directed the company's program which helped produce the *Redstone* and *Jupiter-C* missiles and parts.

Dr. Marshall H. Brucer: Named to receive the U.S. Atomic Energy Commission citation for outstanding service to the nation's nuclear energy program. He is a physician and research specialist in nuclear medicine and radiological physics.

H. Fred Goelzer: Appointed general manager of The Marquardt Corp.'s Pomona Div.

John S. Cromie: Elected vice president of sales for the Catalytic Construction Co. He is a member of the board of directors.

David L. Coddington: Appointed a director in the executive marketing directorate of Page Communications Engineers, Inc. He is also a vice president.

Robert S. Kelso: Elected to the board of directors of Cornell Aeronautical Laboratory, Inc. He is director of its Experimental Facilities Div.

G. Harold Metz: Appointed vice president-corporate personnel of the American Bosch Arma Corp.

George Desloge: Appointed president of Watlow Electric Manufacturing Co. He succeeds **Louis Desloge, Sr.,** who will continue as chairman of the board and treasurer.

William F. Masterson: Named director of operations at Cook Electric Co.'s Tech-Center Div.

Dr. Daniel Alpert: Elected to the board of trustees for the Institute for Defense Analyses. He is professor of physics at the University of Illinois and dean of the university's graduate school. Also elected to the board were **Robert C. Baker,** president of the American Security and Trust Co., Washington, D.C., and **Dr. Herbert F. York,** vice chairman of the President's Scientific Advisory Committee and professor of physics at the University of California at San Diego.

Robert H. Ossyra: Appointed a division manager in the propellants division of Amoco Chemical Corp.

Dr. Julius A. Stratton: Elected a director of the Westinghouse Electric Corp. He is president of the Massachusetts Institute of Technology.

Dr. Wernher Von Braun: Named chairman of the International Sponsors Committee of the Robert Hutchings Goddard Library Program at Clark University in Worcester, Mass. He is director of the George C. Marshall Space Flight Center.

Herbert A. Elion: Appointed director of a newly established instrumentation laboratory at the GCA Technology Div. of GCA Corp.

—when and where—

JUNE

International Symposium on Global Communications (GLOBECOM VII), sponsored by the University of Colorado and National Bureau of Standards, Boulder, Colo., June 7-9.

Ocean Science and Ocean Engineering Conference and Exhibit, sponsored by The Marine Technology Society and The American Society of Limnology and Oceanography, Washington Hilton Hotel, Washington, D.C., June 14-17.

Propulsion Joint Specialist Conference, sponsored by the American Institute of Aeronautics and Astronautics, Air Force Academy, Colorado Springs, Colo., June 14-18.

Tenth Anniversary Scientific Seminar, sponsored by the Air Force Office of Scientific Research in cooperation with the University of New Mexico and the Air Force Missile Development Center, Cloudcroft, N.M., June 14-25.

1965 Heat Transfer and Fluid Mechanics Institute, sponsored by the American Institute of Aeronautics and Astronautics, Los Angeles, June 21-23.

Eighth Annual Conference on Vacuum Metallurgy, sponsored by the American Vacuum Society, Barbizon Plaza Hotel, New York City, June 21-23.

1965 Aerospace Technical Conference and Exhibit, sponsored by the Professional Technical Group on Aerospace and the Institute of Electrical and Electronics Engineers, Shamrock-Hilton Hotel, Houston, June 21-24.

M/R BUSINESS OFFICES

Washington, D.C. 20005—1001 Vermont Avenue, NW; (202)783-5400
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ERC Looks to 1970's

TWO WIDELY SEPARATED but related events took place during the third week of this month. On May 19, the guidance system of a *Little Joe II* booster went haywire and sent the vehicle into an accelerating roll which tore it apart some 25 seconds after lift-off from White Sands Missile Range, N.M.

At the same time, the *Mariner IV* spacecraft was communicating with Earth across some 84,000,000 miles of space as it hurtled away from this planet at a million miles per day, bound for a historic fly-by of Mars on July 14.

The connection? Electronics—and the reliability thereof.

The *Little Joe II* breakup—which, incidentally, provided a fine if unscheduled test of the *Apollo* emergency launch escape system—demonstrated that even in a test program as rigidly controlled as *Apollo*, one well within the state of the art, there is no such thing as 100% reliability. Perfection is impossible, although the *Saturn* team with a ninth straight successful launch seemed determined last week to prove otherwise.

Mariner, on the other hand, showed that the determination of man, and his ever-increasing knowledge of electronics, can overcome seemingly impossible obstacles.

One need only contemplate what *Mariner* has done, and what it is designed to do, to appreciate this. Some 20,000,000 separate measurements have been made to date by *Mariner IV*. The spacecraft has returned data on radioactivity showing that, so far along its flight path, man could safely have survived the Martian journey. Cosmic dust detectors, on the other hand, show the number of hits from cosmic dust rising exponentially on the outward voyage.

Already, technicians at JPL have overcome one troublesome habit of the spacecraft, its refusal to stay locked on Canopus—a fix achieved over millions of miles of space. A mid-course correction maneuver has been successfully executed so the spacecraft will swing closely enough behind the red planet to permit transmission through the Martian atmosphere, enabling determination of atmospheric pressure and aiding in future design of landing capsules. It is hoped that *Mariner IV*'s television camera will relay to Earth a look at those baffling canals, the polar ice cap and the Martian desert.

Consider, however, the unknowns which still may affect the electronics of this remarkable craft. Are there radiation belts near the planet, similar to Earth's radiation belts, which can affect the Canopus tracker and other instruments sensitive to radiation? Will delicate electronic devices function after lying dormant for seven and one-half months?

Or consider the difficulties of communicating with *Mariner* from Earth when it is in the vicinity of Mars, some 130,000,000 miles distant. If some device aboard the spacecraft fails to work, it is 12½ minutes before news of this is communicated to Earth. After a decision on a fix, 12½ minutes is required to relay this to the spacecraft. Another 12½ minutes then must pass before JPL technicians will know if their fix has worked.

Between White Sands, N.M., where *Little Joe II* showed failures must be expected even well within the state of the art, and Mars, where *Mariner IV* faces the electronic gremlins of outer space, lies a vast gap in electronics knowledge.

IT IS THAT GAP that the new Electronics Research Center of the National Aeronautics and Space Administration, subject of the special report in this issue, is designed to fill.

ERC is not concerned with the electronics of the *Apollo* manned lunar-landing program. *Apollo* should land on the Moon well before ERC can make its presence felt on the electronics scene.

ERC's scientists and technicians will be looking instead toward the post-*Apollo* period and the electronics problems of the 1970's.

It is true that ERC's Systems Laboratory will be carrying out support activity directed toward engineering goals and work under way at NASA's various other centers. But this is an exception rather than the rule at ERC. More typical is the work of the Guidance Laboratory, where a major impetus for improved gyro reliability and performance is the expectation that planetary missions of the late 1970's will demand gyro drift rates limited to about 0.0001 degree per hour and mean-time-between-failure durations of 1,000,000 hours. This compares with present capability of 0.1 degree per hour and current MTBF levels of 1,000 hours.

A look at some of the areas of interest to ERC indicates its orientation to the way-out problems of space electronics.

A contract to be let next month is for feasibility study of a thin-film space-charge-limited triode, considered one of the most promising new microelectronic devices.

With materials closely linked to almost every phase of advanced electronics, ERC will begin in FY '66 a broad research program into such areas as semicondutcors, magnetics and dielectrics.

ERC is expected to launch a program next year involving evolutionary development of spacecraft rendezvous and docking radar with acquisition ranges to 200 n. mi. and automatic docking capability.

It should be noted that many of these projects already are in hand despite difficulties ERC faces in acquiring some of the urban renewal land set aside for its Cambridge, Mass., site.

Congress, having made the decision on a go-ahead for the new center and on its location, should not withhold ERC's FY '66 construction funds as it is doing. The die has been cast. The money is needed so that planning can proceed, notwithstanding temporary problems over site acquisition.

Congress should recognize that the need to push back the electronic frontiers of space is imperative. The journey to Mars is a long one.

William J. Coughlin

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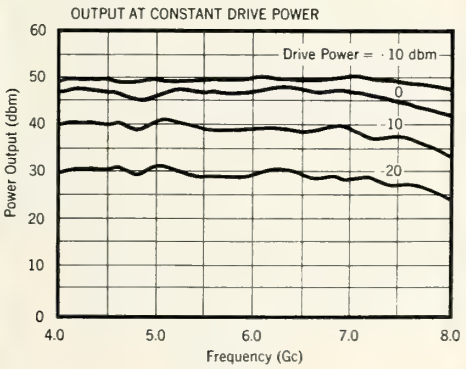

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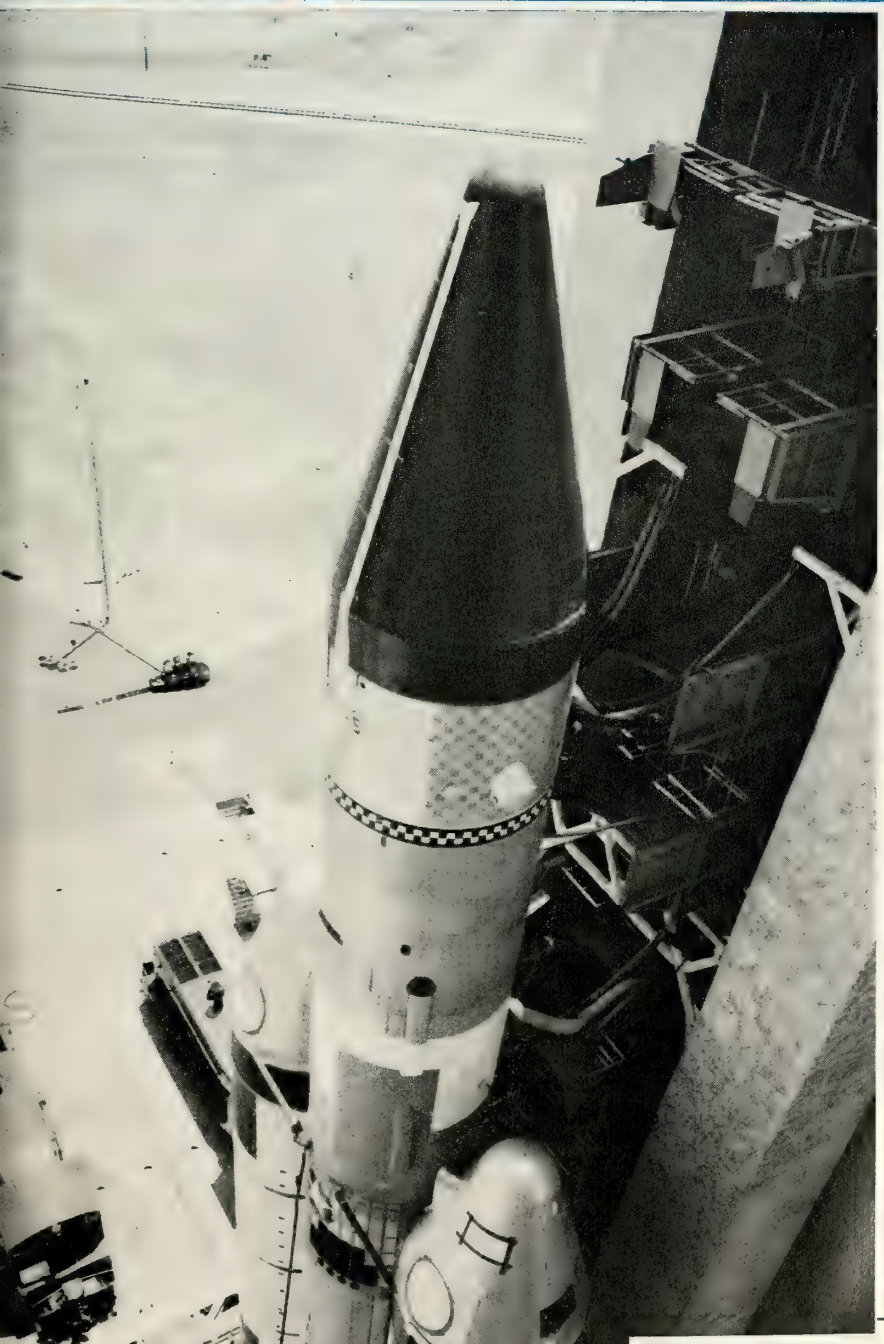

White's Walk In Space Is Success

Immediate MOL Initiation Sought

AES Feasibility Studies Imminent

Optical Imager Eyed as Radar

First AF Titan III-C Poised for Launch

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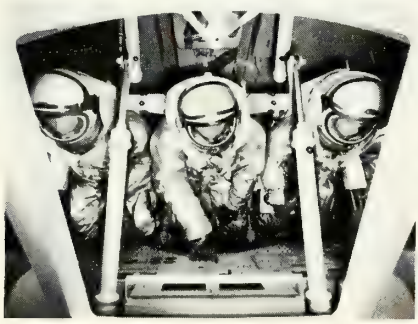
(ACE-S/C: Acceptance Checkout Equipment-Spacecraft)



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Ground Base Design — B.S. in Civil, Mechanical or Architectural Engineering, 2 to 5 years' experience with large booster launch systems and facilities. Will analyze and design integrated structures, handling and facilities equipment for complex and advanced systems.

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Electronics — Senior design and specialty positions are available in: control systems design and analysis, airborne and ground packaging, circuit design and analysis, hydraulic controls design and inertial systems. Others include digital systems, solid state circuits, telemetry, thermal and vibrations analysis, antenna design applications, space power systems and solid state logic systems. Assignments will require B.S. or M.S. and 3 to 10 years' experience in applicable aerospace fields.

Base Electrical — B.S. in E.E. with 3 to 8 years' experience involving design of electrical power installations, electrical ground cable and missile interconnecting systems, switching and distribution units. Will develop specifications, test requirements and analysis of flight data.

Guidance/Flight Mechanics — Several key, senior positions available demanding 3 to 8 years' aerospace experience with B.S. and graduate work preferred. Assignments will involve technical investigations of trajectory shaping, payloads, sizing, orbit mechanics, staging and launch analysis, penetration aids, stability, guidance concepts and error analysis.

Aerothermodynamics — Join activities of a group concerned with the aerodynamic design, testing and analysis of launch vehicles and strategic weapon systems. Experience in subsonic to hypersonic speeds, ascent and orbital flight, flow problems, verification of calculations, and unsteady loads and pressures. Advanced degree desired with 7 years' applicable experience necessary.

Propulsion Systems — Several senior positions requiring 5 to 7 years' aerospace experience in Liquid Engines or Solid Motors with B.S. required and graduate work preferred. Assignments will involve subsystem design and development, performance prediction and systems integration and testing for advanced, complex space booster systems.

Propulsion Analysis — Analytical capability applied to propellant feed systems, radiant heat transfer, zero G environment conditions, compressible flow, thermodynamic and pressurization systems with aid of computer techniques to develop unique answers for advanced, large booster propulsion systems. B.S. or M.S. in Aero, Chem. Eng. or M.E. plus 5 to 10 years' proven technical experience is required.

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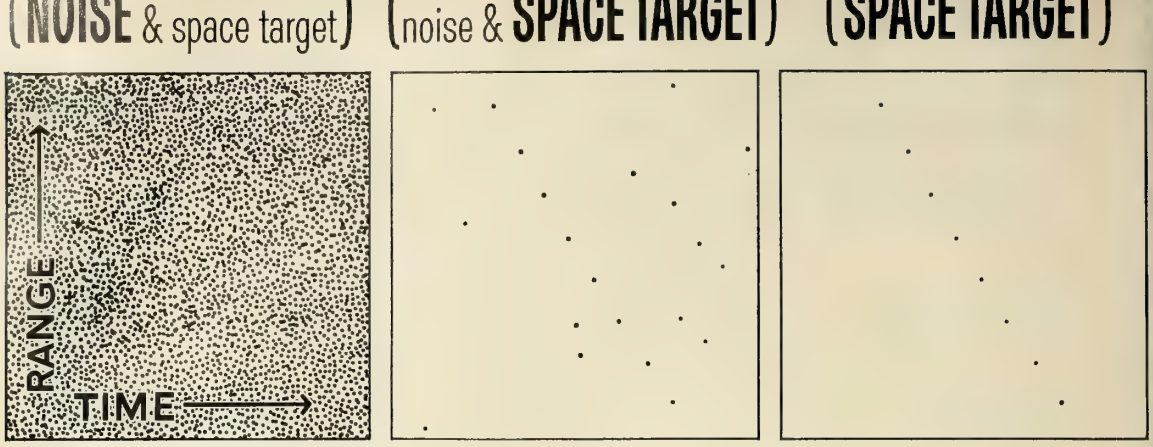

Charts show real-time elimination by computers of noise from radar range data: left, raw data; middle, first stage of filtering; right, noise-free space target trajectory.

Space objects can be tracked by sending radar pulses and observing reflections. But such reflections are accompanied by thousands of "noise" signals from the sky and from the radar receiver itself—especially when the threshold of detection is set low enough to pick up very small or very distant objects. For accurate tracking it is essential, of course, to distinguish reliably between the target signals and the noise.

A new data processing system developed at Bell Telephone Laboratories performs this separation of "real" signals from "noise" signals, and does it in "real time." A human being performing the calculations depicted above would require three weeks.

A computer compares the received pulses following each transmitted pulse with those following the next succeeding transmitted pulse. Those received pulses of the first train which have corresponding pulses in the succeeding train are then retained; the others are rejected. Such correlated data result in the information shown in the middle chart.

Next, another computer compares the correlated data resulting from the transmitted pulses constituting one "look" at a given section of the sky with the correlated data on subsequent "looks" for the same section of the sky (although enlarged somewhat to allow for motion of the space object), again checking for correlation and when none is found rejecting the data. The third chart shows the resultant noise-free data of a space target moving through the sky.

For this military project, engineers at Bell Laboratories, working closely with engineers of the Univac Division of Sperry Rand Corporation, designed and programmed the computers. Because of the demanding requirements of reliability and speed, they developed for it new high-performance semiconductor and magnetic memory components. The two groups combined talents with engineers of the Western Electric Co., the manufacturing unit of the Bell System, to build prototype computers.

This type of coordinated performance is typical of the Bell System's ability to contribute from its broad technical competence to the strengthening of the nation's defense.

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missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 23 June 7, 1965

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THE COVER

Air Force Titan III-C is poised for launch June 17 at Cape Kennedy's Complex 40. The vehicle will be powered at liftoff by nearly 2½ million pounds of thrust from the United Technology Center booster rockets on each side of the payload-carrying, Martin-built core structure.

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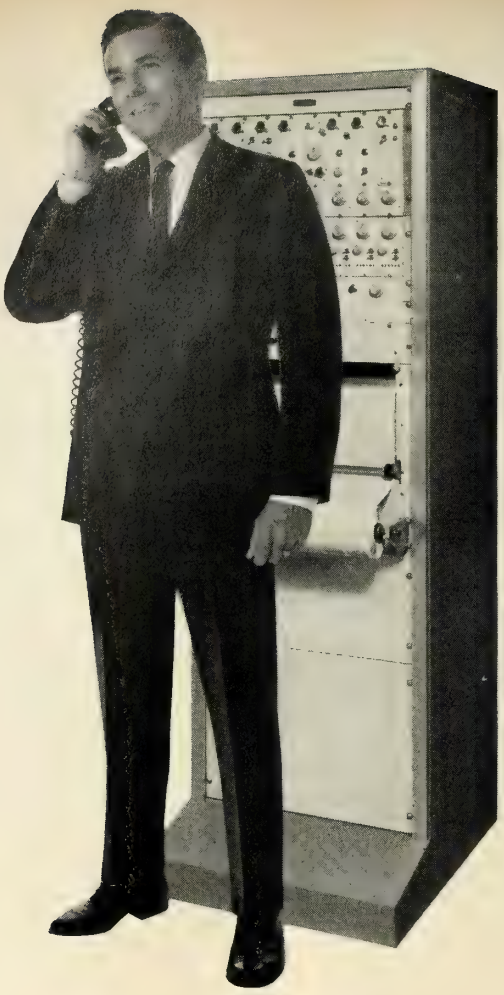

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letters

Hazards of Brevity

To the Editor:

In a letter to the editor in M/R, May 17, Mr. William A. Koch of Aberdeen, Md., indicated that a good abbreviation for million-pound-thrust might be "mpt."

It behooves us all to check recommended practice before suggesting our own abbreviations. The International Committee on Weights and Measures has recommended, and is backed by long-standing practice that M (capital) be used for abbreviating million.

In this "initial ease" industry we have far too many abbreviations to contend with without trying to figure out every Tom, Dick and Harry's personal hieroglyphics.

C. Dean Hermansen
Murray, Utah.

Apollo Proposed for MOL

To the Editor:

I have been reading with interest the M/R articles on the USAF hardware development plans for the *MOL*.

Since Space Systems Div. planners have envisioned the use of a *Gemini-B* for the program, I can see their objectives in getting the much-delayed program under way with two now-available *Gemini* spacecraft. In the same vein, it now appears that initially the payload trade-off may permit a larger laboratory module than originally envisioned (M/R, May 3, p. 15); consequently, I would like to cast my vote for the SSD to phase in, at the earliest moment, a basic *Apollo* Command Module as the spacecraft for *MOL*. My reasons follow:

1. If the decision is made in the near future, I believe that NAA in Downey could furnish Command Modules in time to meet *MOL* development schedules in late '66 or early '67. Consequently, maximum use would be made of NAA/NASA-developed spacecraft technology.

2. Since the spacecraft represents, primarily, a crew carrier, the Command Module could possibly be modified to carry four or more astronauts, thereby phasing into an enlarged *MOL* with the required manpower.

3. Item #2 above would provide more men for the tasks and evaluations to be performed; consequently, the product of the program would be enhanced.

4. Payload/launch considerations, i.e. weight with *Apollo* should be alleviated by present *Titan III-C* expansion and utilization plans for the solid strap-on segments.

5. Eliminating the *Gemini* "hole in the heat shield" problem that, at least to me, appears to be an engineering problem that could cause some unacceptable short- and long-term situations.

6. *Apollo* would eliminate the crew transfer and re-entry problem implied above by performing an *Apollo*/LEM hook-up maneuver (Command Module separates from the *MOL*, *Apollo* completes a 180-degree pitch maneuver with subsequent docking and transfer through the egress lock).

Note: It would appear that if a docking attachment could be located on the underside of the *MOL*, then the spacecraft could be maneuvered to an optimum position/attitude to be used for crew quarters, etc.

7. Furnishing, initially, a space rescue capability with the larger *Apollo* spacecraft. With provision of a second docking attachment/hatch, a minimum *Apollo* crew could remove two or more incapacitated astronauts from the *MOL*.

Michael E. Mulligan
Lt., USAF
Amarillo AFB, Tex.

'Honor Without a Profit'

To the Editor:

I have read with considerable interest your editorial on "Honor Without A Profit," MISSILES AND ROCKETS, May 10, 1965. Your editorial helps to put into proper focus the environment and policy direction governing Air Force relations with not-for-profit and systems engineering corporations.

B. A. Schriever
General, USAF
Commander
Air Force Systems Command
Washington, D. C.

Cosmos Confusion

To the Editor:

The information rendered by a group of Soviet scientists at the meeting of the American Astronautical Society in Chicago May 4-6, and reported on by M/R (May 10 issue), contains several discrepancies.

First, the *Cosmos 41* satellite apogee altitude is 24,756 statute miles, not 40,000 miles, and the difference is significant. One should compare and observe the similarity of the orbital parameters of *Cosmos 41* with those of *Molniia I*, the USSR Comsat, and further observe that *Cosmos 41* was launched just before the 1964 Olympic Games. With little study one reaches the conclusion that *Cosmos 41* is a Soviet Comsat that failed to perform.

Second, the satellite *Cosmos 4* was in orbit for only three days, not a year. It was launched on April 26, 1962, and recovered on April 19, 1962, as announced by the USSR. Its orbital interval was some 69 hours in length. *Cosmos 4* was one of two precursors to the *Vostok III* and *IV* flights, *Cosmos 7* being the other. *Cosmos 7* was in orbit for four days, to duplicate the *Vostok III* flight as *Cosmos 4* duplicated the *Vostok IV* flight. The Soviet Union often, if not always, has unmanned precursors to its manned flights. Which, incidentally, supports the proposition that they are thorough and careful in their manned flight program.

Saunders B. Kramer
Sunnyvale, Calif.

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The Countdown

WASHINGTON

Competition Seen on Shillelagh

Second-sourcing may come in the Army's *Shillelagh* program as early as Fiscal 1966. That's the word from the Army. Brig. Gen. J. A. Goshorn, director of procurement, told Congress in just-released testimony: "We might go competitive on the entire missile or we might possibly have an extremely aggressive breakout program." Army says Philco Aeronutronic was given the first production contract without introducing competition to avoid significant delay in the FY '65 program.

Several Firsts for Gemini-Titan 4

In addition to Astronaut Ed White's casual stroll in space, the *Gemini-Titan 4* flight chalked up several lesser firsts. One was live broadcast of conversations with the capsule, including the rollicking extravehicular activity. Another was the use of the *Early Bird* communications satellite, which at one point enabled television viewers in the U.S. to watch Britishers in London as they watched the launch from Cape Kennedy via *Early Bird*.

Army Official Backs Limited Nike-X

A limited but widely-deployed version of the *Nike-X* would provide better protection for the U.S. than the same money put into a less extensive, higher-priced system. That belief was stated by Lt. Gen. William W. Dick, Jr., Army chief of research and development, to the House subcommittee on military appropriations. Presumably, he was referring to a limited building-block system using only *Zeus* as an intercept missile, with provisions for addition of *Sprint* and other improvements later (M/R, May 31, p. 17).

Mauler Decision Is Due This Week

Decision on whether development of the *Mauler* missile will continue is to be made this week by an ad hoc board of general officers representing all Army staff elements and potential using commands. This group will resolve differences in evaluation of the situation by the Combat Development Command and the Army Materiel Command. It has the authority to terminate the *Mauler* project; if development is recommended, the decision must be approved by Dept. of Defense.

Air Force Likes Bullpup in Viet Nam

One of the top Air Force pilots back from Viet Nam says use of the *Bullpup* missile aboard the F-105 aircraft has proven very effective in Viet Nam. This echoes a Navy opinion of *Bullpup* performance (M/R, May 31, p. 11). *Bullpup* has been a good weapon against hardened radar-controlled anti-aircraft emplacements, other hardened radar sites, Viet Cong ferries, large boats and ships, and certain bridges. It is not considered effective against steel-reinforced concrete bridges, although a follow-on version due in Viet Nam is expected to be an improvement in this regard. Bonus effect: *Bullpup* has turned out to be a good anti-personnel weapon because of high fragmentation, although cost would rule out its use solely for this purpose.

Lance May Get Go-Ahead This Year

First production of the *Lance* missile may get under way in FY 1966. Although not included in the '66 budget, funds for production may be reprogrammed if tests ending this month are successful. In addition to Army interest, Navy is said to be seriously considering purchase of *Lance* in quantity as a landing support weapon system.

Studies of XB-70 as Launcher Continue

Study of the supersonic XB-70 as a first-stage launcher are continuing at North American Aviation. These show the aircraft could place one-ton payloads in orbit with *Minuteman* as the second stage. Existing liquid boosters launched from the research aircraft could put four-ton payloads in orbit. Studies also show that a lifting body test vehicle could attain speeds of nearly 8,200 mph in launch from an XB-70, and manned winged vehicles weighing up to 12,000 lbs. could be launched into orbit.

INDUSTRY

EOS Delivers Laser Beacon Prototype

Electro-Optical Systems has delivered to NASA's Flight Research Center, Edwards AFB, a prototype of the first laser beacon designed for use on high-performance aircraft. This may be mounted on the *X-15*. It will send wide, coherent spherical wave fronts to ground tracking stations for in-flight azimuth and elevation angle data. The beacon, when coupled with optical ground trackers, will provide azimuth and elevation angle data over a range of 300 n. mi. and down to zero elevation.

Lockheed Opens New Hypervelocity Tunnel

Lockheed-California Co. soon will begin operation of a hypervelocity shock tunnel capable of testing vehicles at Mach 35. The Rye Canyon installation is believed to be the largest of its type in private industry. It will be used for testing both advanced aircraft and spacecraft configurations, including recoverable boosters and maneuverable reentry vehicles. Test section is 9 ft. in diameter.

INTERNATIONAL

COSPAR To Meet in Vienna in 1966

Congress on Space Research (COSPAR) decided in Mar del Plata, Argentina, site of its recent International Space Science Symposium, to hold its 1966 meeting in Vienna. Tokyo was ruled out because delegates felt it would be difficult to obtain travel funds for a second consecutive meeting so far from western Europe.

Argentina Plans Rocket Base

Argentina plans to develop a sounding rocket launch base on the Atlantic Ocean, near its seaside resort of Mar del Plata. It is expected to be operational by mid-1966.

French Tracking Net Is Operational

First two stations of the French *Diane* satellite tracking network now are operational in Pretoria (South Africa) and Colomb-Béchar (Sahara). Built by Compagnie Francaise Thomson-Houston, both stations are operated by the Centre National d'Etudes Spatiales. The French say that a CFTH-patented synchronous reception method has reduced noise level 400 times compared to existing U.S. tracking stations, permitting pickup of signals 20 times weaker or 20 times farther away than previously possible.

First Firing of French Engine Next Year

First static firing of the complete liquid hydrogen-liquid oxygen rocket engine under development by France's Societe d'Etudes de la Propulsion par Réactions (SEPR) at its Melun-Villaroche facility is expected in 1966. Subsystems now are under test. Each of four nozzles of the engine will provide 3,300 lbs. of thrust with one turbopump.

GAO Policies Hit

The General Accounting Office will be called by the House Military Operations subcommittee June 10 to answer charges by defense contractors and the Dept. of Defense of meddling in management matters under guise of its audit function.

Industry witnesses appearing before the subcommittee chaired by Rep. Chet Holifield (D-Calif.) during the second week of the probe into the effect of GAO's audit activities made it clear that they felt the GAO was overstepping its role in a manner detrimental to the defense establishment.

"We feel that the GAO, whether or not in accordance with what Congress desires it to do, has become unduly involved in the exercise of managerial opinion both as to management judgments by the procuring agencies and management judgments by industry," Aerospace Industries Association president Karl G. Harr, Jr., told the subcommittee. This opinion was seconded by H. M. Horner, chairman of United Aircraft Corp., Daniel J. Haughton, president of Lockheed Aircraft Corp., and Howard W. Neffner, vice president of The Boeing Co.

A suggestion by Harr that a firm of management consultants or a Government office for management studies make reviews on the management issues received some favorable comment from the committee. Such a group, United Aicraft's Horner emphasized, should not bear the title of GAO, which he characterized as having a "catch the crook" connotation in the eyes of the public.

The greatest concern, Harr indicated, is that opinions may masquerade as facts because of GAO's power. The GAO's role now has come to be that of detective, prosecutor, jury, judge, and executer and publicizer of its opinions in the field of management, he said.

Harr called for Congress to remedy this situation. He said that the AIA feels that the true function of GAO, protection against dishonesty, fraud, or simple mistake, must be protected. But he emphasized that GAO "should not attempt to fulfill the role of management consultant rendering opinions as to the professional and management judgments of those who are charged with making such judgments."

The subject of trial by publicity—the tremendous pressure put upon the contractor or agency by GAO's policy of publishing its reports and distributing them through the Congress and the press, was hit by several industry witnesses. Harr pointed out that in the midst of disagreements between the GAO and the contracting agency, the contractor "often gets the most damaging adverse publicity even though he was scrupulously following the policies of the procuring agency."

He charged that "it injures and degrades a company to be publicly spanked for alleged misfeasance and malfeasance particularly when the allegation may not only be totally disproved, but may concern only a small part of a tremendously well-done job for which the company receives no public credit."

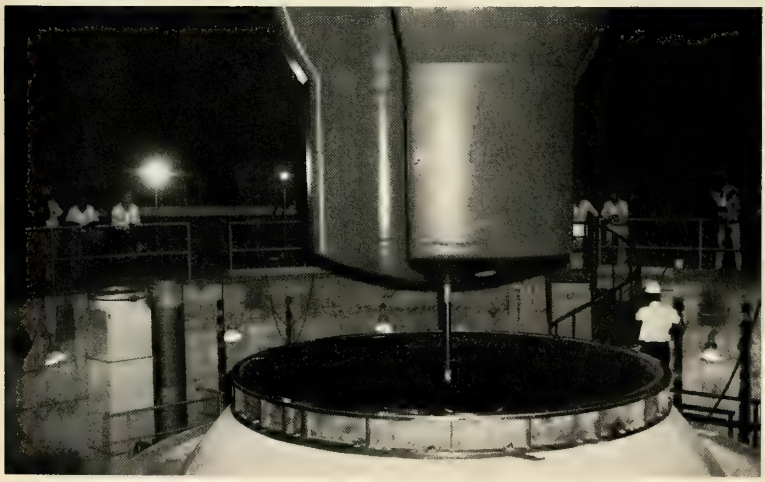
Harr also reiterated a point brought up by DOD itself and apparently shared by the subcommittee, that integrity of contracts is violated if the Government does not speak with one voice.

Boeing's Neffner also brought up this point, asking the question "should the 'opinion' of the man who wasn't there be permitted to destroy the integrity of a contract entered into in good faith?" Most GAO cases, he said, involve disagreement with the judgment of negotiators in evaluating and using the available cost or pricing data. These do not charge that data was incomplete, inaccurate, or out of date, but a mere difference of opinion, he indicated—"hindsight versus foresight."

Horner also raised the point that GAO in some cases "displays a tenacity so great as to throw doubt upon the objectivity of its function as an auditor." He related that in a case in which United Aircraft used Navy machine tools at no cost for reasons agreed upon by UAC and the Navy, the GAO thirteen years after the contract was signed and six years after it was closed out, issued a report claiming a cash rental was due.

During the period of five years in which the GAO investigation was held, he said, three preliminary reports, each claiming rental to be due "under theories differing from each other," were prepared by GAO.

"It has seemed to us that in this case the GAO has been much more interested in seeking a justification for its preconceived position than in conducting an impartial audit," Horner said.



Core for Aerojet 260-in. Motor Installed

THE CORE FOR the 260-in. solid rocket being lowered into the motor case near Aerojet-General Corp.'s Homestead, Fla., plant May 26. The case rests on a thrust ring inside the 177-ft. firing pit. The ring, in turn, is atop three load-measured cells of the greatest capacity ever calibrated by the National Bureau of Standards. Static firing of the motor is to occur in mid-August and is expected to produce 3 million pounds thrust.

Shots of the Week

Explorer 28, NASA's latest *Interplanetary Monitoring Platform (IMP-C)* satellite, was successfully

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set into orbit May 29 by a *Delta* launch vehicle. Apogee achieved was 164,000 miles; perigee, 120 miles. Period is 5 days, 22½ hours, and inclination is 34 degrees.

- Army artillerymen on May 26 successfully fired a *Pershing* ballistic missile from Gilson Butte, Utah, into the White Sands Missile Range, N.M., some 400 miles away. The instrumented warhead impacted in a predetermined target area.
- An Air Force *Atlas* ICBM carrying a piggyback research satellite blew apart shortly after launch from Vandenberg AFB, Calif., May 28.
- The Sandia Corp. launched four *Nitehawk* rockets from the Cook Islands in the South Pacific (p. 27) to make observations of the solar eclipse May 31.
- Astronauts White and McDivitt were lofted into orbit aboard the *Gemini 4* spacecraft June 3 (p. 14). The GT-4 mission called for a total of 62 orbits.

NERVA Fired for Third Time

The NERVA nuclear rocket reactor (NRX-A3) went through its third re-start and run at Jackass Flats, Nev., May 28th. The total operating time was about 43 minutes, with seven minutes at more than 40% of design power (1,100 megawatts).

The test involved several control system experiments to map the operations regions of the reactor up to about 45% of design power and to determine various control system response characteristics in the low and intermediate power regions.

The reactor, designed and built by Westinghouse Astronuclear labs for Aerojet-General Corp. will now be dismantled for detailed examination.

Paris Show To Stress Space

International cooperation in space is expected to be a strong theme of the Paris International Air Show, which opens officially June 11 at Le Bourget, France.

Nearly 450 exhibitors from the world's aerospace industry will be on hand at the bi-annual show—making it the biggest venture of its kind to date in the world, including the British show at Farnborough held on alternate years. Missile/space exhibitors will total 82, compared to 36 in 1963. At least 15 countries will be represented at the 10-day show.

The U.S. display will include exhibits from 38 companies. The Department of Defense will have flying demonstrations and static displays of some 40 aircraft and will cooperate on a Business Information Center with the Department of Commerce. Missile/space equipment to be shown will include the *Titan II, Atlas* and *Agena,* a number of guided missiles, communications satellites, lunar spacecraft, technological satellites and ground support equipment. NASA will not participate in this year's show.

The Soviet Union—after a last-minute request for display space—will exhibit other than aircraft at the show for the first time. Although details are not known, the Soviets reportedly will display a *Vostok* space capsule and Cosmonaut Pavel Popovitch will be at the exhibit stand throughout the show.

British participation will include displays by 56 member-firms of the Society of British Aerospace Companies, various government departments and the R.A.F. They are expected to emphasize a British readiness to cooperate internationally, particularly on an Anglo-French basis. On display, Britain will have a *Bloodhound* service unit, *Blue Streak* and *Skylark* guided missiles; RZ-2, Gamma 303 and 605 rocket engines, models of the *Sea Dart* ramjet and models of technological satellite launchers and space booster vehicles.

The French display will include major exhibits by the French National Center for Space Research (CNES) and the Delegation Ministerielle a l'Armament. Included will be the *Belier, Centaure, Dragon, Eridan, Berenice, Tacite, Veronique 61, Vesta* and *Rubis* sounding rockets; *FR-1* and *D-1* satelilites; the third-stage *Diamant* and second-stage *Coralie* rockets for the ELDO booster.

Molniya Orbit Altered

The Soviet Union has disclosed that its *Molniya I* communications satellite was placed in a new orbit on May 2. Purpose was both to extend the reception time and to make the satellite available at a more convenient time of day.

The satellite was launched April 21 for communications between Moscow and Vladivostok. New orbital parameters are: apogee, 39,957 km.; perigee, 548 km.; inclination, 65 degrees; and period, 12 hours.

O_2-He Systems Pondered

Increased research effort in use of helium instead of nitrogen in two-gas spacecraft atmospheric systems was noted by industry observers at

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the recent Space Electronics Symposium in Los Angeles.

Douglas Aircraft Co.'s Missile & Space Systems group will start an Air Force-funded experimental program next month, using an oxygen-helium system to simulate a spacecraft atmospheric environment for four men. Since the life support equipment involved is contained inside the Douglas simulator and is maintained by the crew, the simulation is expected to produce more realistic data than obtained when the atmosphere is pumped in and controlled from the outside.

Long-term simulation studies at the School of Aerospace Medicine to check out the apparent advantages of helium over nitrogen indicate helium has no adverse effects on the body and causes no significant alterations in breathing or metabolic functions. Since the body absorbs much less helium than nitrogen, bends are a less likely result of decompression. Helium also offers advantages in the life support power equipment, requiring less cooling for astronaut comfort because of its greater thermal absorption capability, spokesmen pointed out.

One item of Air Force concern with helium is that it can leak through small openings faster because of its lower density. Industry spokesmen said Navy's Sealab experiment at Scripps Institution of Oceanography will be watched closely this summer since the underwater atmospheric system will use 80% helium with 4% oxygen and 16% nitrogen.

MM Wing To Go Operational

Minuteman Wing 5 is expected to be operational within 30 days at Francis Warren AFB, Wyo.

The Strategic Air Command wing, when activated, will increase the number of *Minutemen I* missiles on alert to 800. Wing 5 will be deployed in three states, Wyoming, Colorado and Nebraska. All future emplacements will involve the advanced *Minuteman II*.

UPI Wants Own Satellites

United Press International is considering the feasibility of developing its own communications satellite system for use in global news coverage.

The wire service plans to follow the lead of American Broadcasting Co., who is already investigating a satellite system for domestic communications (M/R, May 24, p. 10). According to Mims Thomason, president, UPI has consulted with Hughes Aircraft Co. and has concluded that such a system is both economical and feasible.

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White's 'Walk' Highlights Gemini 4

Astronaut spends 20 minutes in space; NASA denies Agena docking plans may be accelerated to be ready for next flight

by Hal Taylor

CAPE KENNEDY—The U. S. has achieved its greatest space feat to date with the walk in space June 3 by Astronaut Edward White during the *Gemini 4* flight. A planned rendezvous attempt will be delayed until the *Gemini 5* flight in August, however.

Although NASA officials denied it, the first actual docking of two vehicles in space may take place during the *Gemini 5* flight.

White made his trip into space during the 7,000-lb. spacecraft's third orbit of the Earth. He romped for 20 minutes on a 25-ft. gold-coated umbilical, taking photos and using a hand-held propulsion unit to power his movements.

NASA was forced to drop the rendezvous between the capsule and the *Titan II* second stage planned for the fifth orbit because too much of the orbiting attitude maneuvering system (OAMS) fuel was used trying to catch up with the second stage before the extravehicular experiment.

An attempt to rendezvous with a pod ejected from the spacecraft will be made during the *Gemini 5* flight. An actual docking maneuver could also be made if the space agency decides to speed up use of the *Atlas*-launched *Agena* target vehicle in the two-man program.

The walk in space was only one portion of the activities crammed into what was expected to be a four-day flight.

Lift-off came at 10:15:59 EST when the Martin Co.'s *Titan II* booster blasted the McDonnell Aircraft Corp.'s *Gemini* capsule into an orbit ranging from an apogee of 158 n. mi. to a perigee of 87 n. mi.

The launch came after a countdown during which there was only one hold. An electrical problem delayed the lowering of the erector for an hour and 15 minutes.

At press time, the flight appeared headed for success with splashdown in the Atlantic Ocean 400 miles south of Bermuda expected June 7.

● **Gemini 5 plans proceed**—Even as *Gemini 4* was making its 62-orbit journey around the Earth, NASA officials were pushing ahead with plans for the seven-day *Gemini 5* mission now scheduled for early August.

Although U.S. officials denied there are any plans to actually dock with an *Agena* upper stage, it was learned here that a live *Atlas-Agena* booster will be on its launch pad during the *Gemini 5* flight.

NASA said that the *Atlas-Agena* would be used only to simulate countdown during the *Gemini 5*. It will be used during the *Gemini 6* mission late this year when current official plans call for the first docking to take place.

It must be pointed out, however, that NASA issued similar denials when the first reports of extravehicular activity on *Gemini 4* were published. The space agency continued to deny the reports until they were officially confirmed one week before launch.

Industry officials here reported that the *Atlas* for the *Gemini 5* countdown will arrive at Cape Kennedy June 17. *Agena* stage 5001 is also scheduled for delivery early this month. Although not designed to fly, the stage is fully instrumented and could be launched. The first official target stage is designated *Agena* 5002. No date has been released for its delivery to Cape Kennedy.

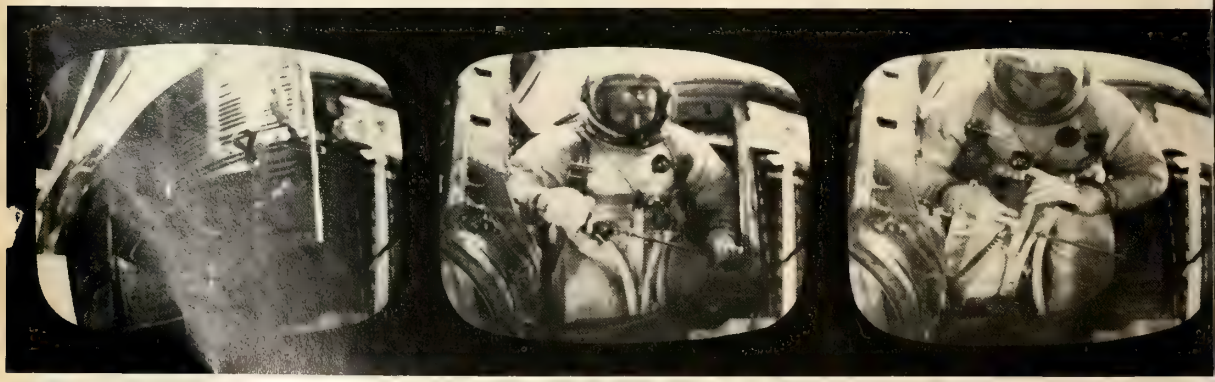
There have been additional unconfirmed reports that certain NASA officials are pushing a plan that calls for extending the *Gemini 5* flight to 14 days.

If docking is accomplished during the presently planned seven-day mission, it would for the first time give the U.S. a clear lead over the Soviet Union in manned space flight activity.

● **Rendezvous scrubbed**—Shortly after second-stage engine cutoff (SECO), McDivitt used the orbital attitude maneuvering system (OAMS) thrusters to damp residual oscillations in the spacecraft/second stage combination. At 30 seconds after SECO, the command pilot initiated a forward separation translation of 5 fps. He continued to fire the OAMS in an effort to get closer to the second stage. He failed, primarily because the stage's tumbling rate—estimated at 30 degrees per second—apparently made its orbit decay.

After consuming one-third of the OAMS fuel, McDivitt abandoned the effort to approach the second stage, and NASA officials announced that there would be no attempt to rendezvous with the stage during the fifth orbit. By the end of the third orbit, it was estimated that the second stage was 65 miles ahead of, and three miles below, the capsule.

McDivitt and White made a spacecraft systems check during the first revo-



ASTRONAUT WHITE practicing Gemini hatch opening, egress, equipment operation and return in McDonnell pressure chamber prior

lution. At the beginning of the second revolution (revolutions are marked by passage over the Cape Kennedy longitude), the crew began to unstow EVA equipment: White's chest pack, tether/umbilical and maneuvering unit with camera.

Then shortly before the EVA experiment was to be attempted, McDivitt decided that the two astronauts' other activities had used too much time, and that it would be better to delay EVA until the third orbit.

● **Preparing for EVA**—After the spacecraft entered the night side of the orbit over the Indian Ocean, the crew de-pressurized it to 2 psia. The suits automatically pressurized to 2.0 ±0.1 psi above cabin pressure. White opened the hatch just after the spacecraft had passed beyond Hawaii. Two minutes before acquisition of signal by the Guaymas, Mexico, station, he stood up and then got the "go" signal to emerge completely from the spacecraft.

He emerged at 2:45 p.m. EST and was back standing in the capsule at 3:05.

White climbed out with the umbilical, placing his right hand in a re-entry control system nozzle and his left hand on the instrument panel ingress bar. On verbal command from McDivitt, White pushed himself away and used the hand-held maneuvering unit to propel himself in space.

White used a 35-mm camera mounted on the handle of the maneuvering unit to take photographs during EVA. He operated the camera with his left hand.

White had to be ordered to return to the spacecraft by Flight Director Christopher Kraft. McDivitt assisted White by pulling in the umbilical. White climbed into the spacecraft, removed the camera from the maneuvering unit, and ejected the umbilical from the capsule. He pulled himself into his couch, closed the hatch and repressurized the capsule before the capsule moved beyond communications range with the Ascension Island Station. Because of difficulty encountered in closing the hatch, McDivitt decided against the planned re-opening of the craft to eject the chest-pack.

On the night side of the orbit, the crew attempted to track the booster visually by observing its two high-intensity flashing lights. The xenon lights of 2.25 million candlepower each are mounted on the mid-section of the *Titan II* stage, and timed to flash 65 times each minute —on for 1/10 of a second, off 9/10 of a second. The lights were turned on for the first time approximately 5½ minutes after SECO. Identical xenon lights will be installed in all *Agena* rendezvous vehicles. These lights can be identified at a maximum distance of 20 miles, according to McDonnell engineers.

At press time, there was no indication as to how successful the effort had been.

White had planned to use a Dept. of Defense hand-held sextant to measure angles between the second stage and known stars throughout the night-to-day transition. MSC officials said the exercise would establish whether a target can be tracked against a background of varying light intensity. The data will be used by the *Apollo* program office to evaluate an optical tracking system for the Lunar Excursion Module. Later in the mission, White also made star-to-horizon measurements for DOD, which is perfecting the lightweight manual sextant for use in autonomous navigation.

● **Maneuvering unit**—The maneuvering unit is held in the astronaut's right hand like a flashlight and operated by finger control on a rocker trigger. Below the handle, stacked one atop the other, are two bailout bottles each containing 0.68 lb. of pure oxygen compressed to 4,000 psi.

Three gas-jet nozzles produce the tractor and pusher forces. A 1.5-in.-dia. bell-shaped nozzle is positioned front center and canted downward just below the handle. This nozzle expels a 2-lb. force, which propels the astronaut backward when he squeezes a rocker trigger on the handle backward. Two smaller, 1-in.-dia. nozzles extend rearward from two 16-in. hollow rods outstretched from the front of the handle in a "T" formation. Each nozzle produces a 1-lb. force, pulling the astronaut forward when he moves the rocker trigger forward.

The unit is designed to produce a 6-fps change in velocity. Total impulse in 40 pound-seconds and operational lifetime is 20 seconds. To operate the maneuvering unit, the astronaut must fire through his center of gravity (4 in. below the waist). The unit is made of stainless steel and high-strength aluminum alloy, and weighs (with camera) about 7.5 lbs. ■

actual walk into space during Gemini 4 mission.

GEMINI 4 lifts off from Cape Kennedy.

House Group Spurs Military Space

Government Operations Committee recommends immediate MOL development, stresses importance of Space Council

by Heather M. David

THE HOUSE Government Operations Committee has urged that the Department of Defense commence full-scale development of the *Manned Orbiting Laboratory (MOL)* without further delay. The committee also exhorted President Johnson to formulate specific long-range national space plans and give more support to the National Aeronautics and Space Council so that it may play a greater role in directing the nation's space programs.

In a lengthy report culminating a study by the committee, it said that it would be a "serious mistake" for NASA to take on management of an orbital laboratory program with overriding military objectives.

In urging the go-ahead by DOD, the powerful committee threw its weight with the members of both Armed Services committees and the House Science and Astronautics Committee. Of the Congressional committees concerned, only the Senate Space Committee has been less specific regarding management of the program. It was at the urging of Sen. Clinton P. Anderson, (D-N.M.) that the study of a possible merger between *MOL* and an *Apollo Extension System* was undertaken by NASA and DOD.

While the committee was adamant about DOD control of *MOL* and expressed its feeling that the agency should stick to the *Titan III-Gemini* configuration instead of shifting to *Apollo*, it recommended that NASA participate, through funding and selected experiments, in the *MOL* project.

It added that its recommendation for the DOD *MOL* is without prejudice to NASA's future requirements for manned space stations, and that it recognized that such stations or laboratories will serve important civilian as well as military space purposes. It stressed, however, that "the compelling need of the moment is to overcome a military lag in space technology."

● **Recommendations**—Other strong recommendations made by the committee, which adopted the actions of its Military Operations subcommittee chaired by Rep. Chet Holifield (D-Calif.), included:

—That DOD drop its official public pretense that certain programs and requirements do not exist in favor of a more realistic secrecy policy.

"A broader dissemination of information on military space technology is necessary in the interests of more informed public support of military space efforts, visible and efficient management, and the application of military technology to the entire space program," the committee said. It scoffed at the military's "fetish" at classifying the names of projects that were once common currency in public discourse.

—That careful consideration be given to achieving economies in space operations through greater standardization of systems and subsystems and through such techniques as recoverable and re-usable boosters and spacecraft.

● **Need for *MOL***—The group made it quite clear that it feels the nation urgently needs *MOL* to catch up with the Russians in technology that may have military significance. While the public equates beating the Russians to the Moon or otherwise matching or excelling the Soviets in space performances with defense and security, the committee said that it is the "solemn obligation" of the policymakers to insure that the space race truly does not ignore military necessities.

Asking "Which agency's needs have the overriding priority?", and pointing out that *MOL* could serve both DOD and NASA, the committee said conclusively that priority belongs to the military. It expressed the conviction that the Soviet Union is "substantially" ahead of the U.S. in this field, as evidenced by the *Voskhod*, which is a space station in certain respects.

An added advantage of an *MOL* under Air Force management, the committee indicated, is that it would "energize and exercise AF resources for space management . . . which have not been fully effective under prevailing DOD policies to restrict new projects or extend unduly the preliminary study phases."

Caution was also expressed against a too-rigorous insistence that operational requirements be defined before permitting developments in new technological areas. The report recommended that DOD "take vigorous action to disassociate hard and fast military requirements from the new but rapidly growing area of space technology." It included nuclear space developments in this admonition.

● **Space Council**—The whole confusion of the manned orbital projects, the group indicated, are evidence of the need for more orderly, systematic planning on a national basis. A strong role should be taken by the Space Council, it recommended. This role should include the Council being the focal point in reconciling interagency conflicts.

In making long-range plans, however, the group stressed that account should be taken of the fact that NASA will continue to be the leading agency for space exploration and development. But it added that military potentials will increasingly emerge and the military role will correspondingly enlarge, and that other agencies, such as the Atomic Energy Commission and the Commerce Department will have important contributions. NASA's responsibility is broad, but not exclusive, the Congressional committee said.

Increasing effort toward tighter and more efficient management is needed in NASA because of the size of its workload and budget, the group also reported. It suggested that to help effect this, an organizational setup somewhat akin to the DOD's Directorate of Defense Research and Engineering should be set up in the Office of the Associate Administrator in NASA.

"A strengthened central office, staffed with persons of unusual competence who are enabled to relate programs into a coherent whole and resolve difficult problems of system choice and interaction is a likely development in NASA management."

Instructive examples in DOD contracting methods developed or expanded under Secretary Robert S. McNamara were cited. The Committee also recommended standardized contracting methods in common with DOD so that procurement can be made more efficient and Government-contractor relationships more harmonious.

The committee likened the problem of coordinating NASA field centers to that of the military services within the Dept. of Defense.

A facet of coordination between DOD and NASA the committee indicated needs attention is that on how reimbursement between the two agencies should be made. Although an agreement was signed in 1959, it has not been reviewed or revised since that time. ■

AES Program Definition To Begin

First step will be award of study contracts to determine feasibility of payload integration, systems and flights

REQUESTS FOR PROPOSALS for the first step in the program definition phase of *Apollo Extension Systems (AES)* will be issued in the next month.

The phase calls for the selection of two or three contractors for four- to six-month parallel studies.

The contracts will call for feasibility studies and preliminary project definition of payload integration for *AES* systems, experiments and flights.

It will be followed by a six- to eight-month final project definition phase with only one contractor. This timetable calls for hardware development with only one contractor to begin next spring.

Space agency officials still have not decided whether the integration job requires more than one firm and one NASA field center. It is certain that the RFP's will be issued by the Manned Spacecraft Center.

If a decision is made to select separate firms to handle Earth-orbital, lunar-orbital and surface missions, it is likely that the latter task would be directed by another NASA center, probably the Marshall Space Flight Center. The first phase contracts will be funded with FY'65 money.

• **Anticipated scope**—*AES* is the space agency's most imminent new hardware development program and it has an estimated cost of more than $1 billion.

Plans call for as many as 20 flights, including Earth-orbital missions of up to 45 days, lunar-orbital missions of three to four weeks and lunar surface missions of up to two weeks.

At the same time the RFP's are issued, separate contracts will be awarded to North American Aviation, Inc., for preliminary definition of the changes *AES* missions will require in the *Apollo* spacecraft's Command and Service Modules and to the Grumman Aircraft Engineering Corp. for similar studies of the changes required in the Lunar Excursion Module and the planned use of the LEM as a shelter for astronauts on the lunar surface.

A decision is expected next spring as to the best way to provide mobility for astronauts on the lunar surface. The Boeing Co. and General Motors are studying a wheeled vehicle weighing 1,000 to 1,500 lbs. for this purpose.

At the same time, Bell Aerosystems is studying a rocket propulsion device astronauts could use for extended lunar exploration.

• **Flight plans**—Plans call for earliest AES flights to be made in 1968.

The first flights would be 14-day orbital *AES* missions that would use basic *Apollo* hardware with no modifications. Block II Command and Service Module and Lunar Excursion Module fabrication for these flights will begin later this year.

Definition of experiments for these flights has already been initiated and development will begin in the last half of 1965. The flights will be scheduled on the basis of the availability of the *Saturn IB* and *Saturn V* boosters, but they will continue through 1969 and into early 1970.

The second group of flights will begin in 1970 and continue in 1971 at a rate of five or six per year. These will be extended orbital missions of up to 45 days. The Command and Service Module life-support and power systems will be modified to provide greater capability. The LEM lab—stripped of its ascent stage—will also be used. ■

Military 'Common Market' Sought

ESTABLISHMENT of a "common market" for military hardware has been advocated by Defense Secretary Robert S. McNamara in connection with NATO sessions in Europe.

Such a common market agreement was proposed last week by the United States defense secretary in discussing "the joint development and joint production" of arms in a move to forestall further criticism of U.S. sales of weapons abroad.

McNamara suggested a common policy within NATO related to arms production—in which military hardware made by one member nation would be available to all members at a uniform, agreed price, with two or more nations encouraged to join in developing and producing weapons systems when such procedure proves advantageous. Criticism of U.S. arms policy has increased in both Britain and France recently—but for differing reasons.

DeGaulle's advocacy of increased political and military national sovereignty finds France likely to oppose consortiums of several nations in the development or production of weapons. Most British dissatisfaction is voiced in the complaint that weapons quality is a factor often obscured by the pressure of price and the hard-sell tactics allegedly employed by some American manufacturers and defense representatives.

McNamara sought to dispel British apprehension during a visit in London prior to the NATO session. He insisted that the U.S. is willing to purchase arms from NATO nations as well as to sell to them. Declaring that the U.S. seeks no special position in the sale of its arms, McNamara said all such procurement should be based solely on the twin factors of price and quality. In conversations with British Defense Minister Dennis Healy, he further emphasized that the U.S. wants its military forces to "buy defense products in the United Kingdom on the basis of cost equality."

McNamara made no effort to conceal his awareness of British and French criticism and at the same time noted that balance-of-payments problems require that the U.S. continue to seek markets in Europe for its weapons production.

In comments on NATO preparedness and strategy, McNamara cited the great importance to NATO of strategic nuclear deterrent in opposition to the Soviet threat. The fact that the bulk of the strategic deterrent consists of "external" forces is less important in McNamara's view. The relevant question is whether the Western alliance is providing the right kinds and amounts of weaponry to counter the Soviet nuclear threat to Europe. In this aspect of NATO defense, the alliance is procuring the right systems in the right amounts, McNamara said.

AF Awaits F-111A Weapons Studies

Advanced fire-control system will be required to accommodate armament of 1970's; early versions to carry existing missiles

by Donald L. Zylstra

DESIGN CONCEPT studies by five companies dealing with the type of fire-control and missiles to be carried by the F-111A aircraft are due for completion June 25, with reports to be delivered July 5 for Air Force and Directorate of Defense Research and Engineering evaluation.

Autonetics Division of North American Aviation, General Dynamics/Fort Worth, Hughes Aircraft Co., Sperry Gyroscope Co., and Westinghouse Electric Corp. are finishing work on four-month study contracts awarded each firm Feb. 24.

These industry studies concentrate on providing concepts for a new fire-control system (Mark II avionics system) for the Air Force version of the F-111 "designed especially to supplant the basic equipment" in the initial production models of the F-111A. Requirement guidelines supplied to the five study contractors were purposely generous, affording the widest possible latitude in both missile and fire-control concepts in an effort to obtain the most technically advanced overall systems.

Contractors have been directed to complete analyses that will lead to a complete, integrated package of recommended designs for items including: a reliable, accurate navigation platform; an airborne digital computer capable of meeting navigation, self-check and delivery requirements; an air-to-air missile compatible with the Mark II avionics system; and augmentation of the present F-111A communications system.

In addition, the work description in the contracts called for a test and check-out subsystem for the total package, with system self-test features and aerospace ground equipment to support the Mark II; an attack radar; an infrared subsystem for search and detection; an optical range tracker; an automatic terrain-following subsystem; and IFF capabilities.

Responsibilities of firms conducting the design-recommendation studies relate equally to the avionics and to the prospective missiles that will be the F-111A's ultimate armament. The Mark II is to be configured to "handle a large majority of the aircraft missiles which will be in the Air Force inventory from the year 1970 forward."

● **Missile mix**—On the missile side, the F-111A will require both air-to-surface and air-to-air systems compatible with Mark II. Although it is designed as a major advance in fighter airframe and propulsion, the F-111A in at least its first two operational wings will be merely an advanced airborne platform for launching currently operational missiles—such as *Bullpup* and *Shrike* in the air-to-surface missile category and the *Sidewinder* air-to-air missile.

Study contractors have essentially three options in their recommendations for missiles to accompany Mark II—use of missiles already in the armed services inventories; introduction of these missiles with minor or major modifications; or the design of entirely new missiles.

Should the latter choice be made and gain Air Force and DDR&E approval, many observers feel that design from scratch of one or more new missiles might seriously delay installation of the Mark II avionics package in operational aircraft.

The current development schedule calls for the Mark II package, complete with missiles, to be installed in the first operational production aircraft in the third wing of F-111A's—or after about the 200th production aircraft, destined to come off the assembly line in the spring of 1969.

If the present goal calling for Mark II in the third wing isn't achieved, presumably such installation could be delayed until the fourth or even the fifth wing of operational aircraft. Air Force spokesmen assert that planned Mark II development is keeping pace with the schedule set for the F-111A aircraft, and both remain strictly on schedule. A program definition phase (PDP) for Mark II begins officially July 5 with the delivery of study reports to the Air Force. It will continue for an estimated eight months before full-scale development actually gets under way.

Although no official word is out, informed sources have indicated that the Pentagon has already made a firm decision to adapt three wings of the planned total of Air Force F-111As to function as medium bombers in support of the aging B-52 and the newer B-58 bombers.

● **Navy version progress**—Navy's approach to fire-control and missile systems for its "B" version of the F-111 calls for inclusion of the Hughes Aircraft Co. *Phoenix* air-to-air missile and fire-control system on the first operational airplanes. *Phoenix* development has been declared the "pacing factor" in operational availability of this aircraft. Unlike the Air Force, Navy is stressing multiple-shot capability in *Phoenix*—a characteristic that could come as a bonus in the current Mark II Air Force studies but is not a prime requirement.

Pulse doppler radar guidance and homing in the *Phoenix* system will presumably use the same antenna for transmitting radar signals and receiving the echoes from incoming aircraft targets. The missile is designed to operate with a pulsed or intermittent signal.

One of the advantages of a pulsing system is the elimination of the necessity to "talk and listen" simultaneously, using a single antenna—thus avoiding the de-coupling and leak-through problems experienced with transmitter and receiver located in close proximity in the aircraft.

Although Navy has kept its *Phoenix* development rigidly classified, many observers interpret the statement that the *Phoenix* missile is "equipped with both semi-active and active guidance" as a clue to the method by which multiple-shot capability is achieved.

● **Phoenix guidance**—Thus, in the initial, semi-active and longest portion of its flight trajectory, the pulse-doppler missile would seek a target illuminated by a powerful pulse from the aircraft. Then, in a much shorter final portion of its flight, guidance would be turned over entirely to the missile itself on command from the aircraft, leaving it to complete its flight to a designated target in the active mode, supplying its own pulse at relatively short range.

Fire-control equipment plus its weapons payload should add an estimated 7,000 lbs. to the already overweight F-111B, which weighed 69,000 lbs. on takeoff for its first flight.

Both the *Phoenix* and the Mark II systems may be equipped with infrared search subsystems and will feature pilot-oriented cockpit instrumentation, displaying the aircraft functional status, as well as providing tactical data visually during target acquisition and weapon delivery. ■

More Powerful Delta Introduced

Re-startable second stage considerably modified to give longer burn time; to be used in GEOS, Pioneer programs

by Sue Butler

CAPE KENNEDY—Douglas Aircraft Co. has unveiled its uprated *Delta 3E* launch vehicle, which has a new, bigger and more powerful second stage.

The new stage, first of eight to be made by Douglas under a $15-million NASA contract signed last August, arrived here May 20 by plane from Santa Monica, Calif. The contract includes about $6 million for modification; the rest is for actual production.

The improved second stage accommodates larger tanks, which will permit nominal burning time to be increased from 175 to 385 sec.

The new stage also has a re-start capability. Its engine is essentially the same as that now used in the *Delta 3D* except that the oxidizer-burst diaphragm has been removed to permit a dry start.

For a second burn in orbit, electrical changes in the programmer will also be made, increasing the outputs from five to six and increasing the programmer time from 1,000 to 2,000 sec.

The shorter but greater-diameter stage has a shortened guidance of Bell Telephone Labs design, made by Western Electric.

A velocity cut-off package, made by Honeywell, Inc., has been added that is set for a specific velocity before lift-off. Once the rocket is out of line of sight, the unit takes over from the BTL guidance and cuts off second-stage burn when the desired velocity is achieved.

● **Missions planned**—A second increment of velocity figures can be programmed into the package, which will perform the same functions after a coast period and second burn of the second stage.

The improved second stage will first fly sometime after July, when an uprated *Delta* will inject *GEOS*, NASA's geodetic satellite. Because it will be a high-energy mission, no second-burn capability is required and the *Delta* will have its usual third stage.

Similar thrust-augmented configurations will be used to launch two *Pioneers*.

The first time a second burn will be attempted will be on *Delta 40* or *41*, containing the fifth or sixth uprated second stage. That *Delta*, minus its third stage but with thrust augmentation, will launch the first *Biosatellite*.

When the large tanks are added to the *Thrust-Augmented Delta (TAD)*, the vehicle will be able to place 1,200 lbs. into low-Earth orbit or 225 lbs. to escape velocity, compared with 100 lbs. for the standard *Delta*.

The new second stage with its bigger tanks will be used for launching payloads in the *Biosatellite, Pioneer* and meteorological satellite family. A *TAD* with the improved second stage, including re-start capability, plus third and even fourth stages, will also be used for launching an anchored *Interplanetary Monitoring Platform* into an orbit around the Moon sometime in 1966, a Douglas spokesman told MISSILES AND ROCKETS.

The nominal liftoff weight of the improved three-stage *Delta* will be 142,569 lbs., 2,081 lbs. heavier than the standard vehicle.

● **Modifications**—The first stage underwent only minor modifications to the structure, electrical power distribution system and flight control. Three rail guides have been added to the adapter section to guide the second stage.

The second stage is 73.5 in. shorter but has a diameter of 54.6 in. and is flaired at both ends.

The stage's thrust in vacuum will be increased from 7,575 to 7,890 lbs.

Douglas's tally sheet shows: Original *Deltas* (36 in. shorter than the standard version) launched, 14; current or standard *Deltas*, 17 launched (including the one for *IMP* May 29) and seven to go (four of these are at the Cape, three still in Santa Monica); and eight improved *Deltas* (one at the Cape and seven more to be built).

Both pads 17A and B are currently undergoing modifications to accept the uprated Deltas. ■

Snapoodle Flight Model Considered for MOL Use

AIR FORCE Aero Propulsion Laboratory is negotiating with TRW Space Technology Laboratories on a contract that will permit development of a prototype Snapoodle system, a combined isotope-fueled space engine-electric power generator incorporating the Poodle thrustor coupled with a thermoelectric converter.

Following prototype development, next step would be development of a flight model that could be used on the *Manned Orbiting Laboratory (MOL)*. Applications include spacecraft maneuverability, maintaining orbit and orbital transfer.

Prototype effort will involve procurement of thermoelectric materials, with STL making a selection between Minnesota Mining and Manufacturing Co., and Radio Corp. of America for the thermoelectric elements. Present design calls for enshrouding the Poodle isotope thrustor with a thermoelectric converter to achieve earliest initial operational capability and highest probability of success.

Design enables simultaneous generation of both thrust and electrical power from a single unit at a higher total thermal efficiency than either component separately, with the heat produced for propulsion available to the power generator on a cost- and weight-free basis. The system will function as an electric power supply after propellant is expended, taking advantage of isotope half life.

STL reports that with an initial fueling of five thermal kilowatts of Polonium-210, 70 watts of continuous electric power for 40 days will be available when Snapoodle is functioning as a thrustor. Used as a power supply, the unit will generate an initial power output of more than 200 watts.

The system also could provide a hot-gas maneuvering capability, the 750-sec. specific impulse substantially increasing the propellant utilization efficiency over cold gas or monopropellant systems.

Merton-Smith in Tijuana

The outside lounge of the La Sierra Hotel in Tijuana, Baja California, from six to nine p.m. on any Sunday during the bullfight season is, or should be, the world-wide headquarters for girl watching. This fact, therefore, made it an exceptionally logical place for Dr. Burton Merton-Smith to be.

He was wearing a single-button blue worsted suit, but the ruffled shirt, the Flamenco boots and the grey flat-top Cordobes hat gave him the appearance of a true aficionado of the bullfights which, indeed, he is.

"Look at that one over there," he said pointing with his salt-rimmed Margarita glass. She was truly smashing—lithe, willowy, with long blond hair. "The world is a marvelous place," he said to me, "filled with the fantastic wonders of nature. Take the bullfight this afternoon. El Conejo was absolutely superb with his paso del pecho."

The waiter came and this time Merton-Smith ordered a straight tequila, with sangrita on the side. I stuck with beer.

"Did you notice, however," he continued, "that the major problem each of the matadores has was with the sword. That's the toughest and most difficult job of the whole fight. One job to do. One single purpose. Straight to the problem."

I rolled my eyes up in humorful submission. I knew it was coming and it did.

"It's similar to small spacecraft," he said, smiling at the blond aura across the hotel patio. "They perform a very precise mission with maximum dispatch—like the sword straight to the problem. Plus, of course, they're inexpensive."

"What's small," I asked.

"Oh, let's say anything up to a hundred pounds," he said. "The whole small spacecraft 'thing' is rather interesting. At Electro-Optical Systems, we've been probing with probes, so to speak—sounding rockets with modular payloads and, of course, LUSTER."

"That is, indeed, a sword thrust," I said.

"True, LUSTER was a beautiful answer to a tough NASA problem. Go up and collect particulate matter above the atmosphere. One small probe. One big job. And it's the same with small orbiting satellites. Flexibility. Adaptability. Ease."

"Are you saying that the big satellites are inefficient," I asked.

"Not at all. For some projects, however, they're like killing the bull with a cannon. Take a small spacecraft, for instance, used to create an artificial comet."

"Shades of Halley," I muttered.

"Indeed," Merton-Smith chuckled. "We send up a small craft which will eject a specific liquid that will be, shall we say, 'disrupted' in the vacuum of space. The resulting globules will, we hope, be representative of an actual comet. Through spectroscopy and continuing experimentation we should be able to duplicate nature and create a truly artificial comet. We'll find out what comets are and how they're made. Did you know, for instance that they contain organic molecules which could give us a clue as to extra-terrestrial life. The whole project would take a number of shots, maybe several dozen, and even at that the cost would be small compared to the prohibitive cost of big satellites. In fact, with a small craft, we can piggyback on some other project at very little cost. My lord, that sweet thing is smoking a cigar."

"I suppose there are countless other experiments suitable for small spacecraft," I said.

"Is anything really countless," he countered. "A good one would be a reflective samples test satellite. Here we'd expose a quantity of metal mirrors and measure their degeneration in space conditions. Another is the determination of the existence of alkali metals in the sun's atmosphere. We can't measure their concentration from the earth's surface because they are, in a way, masked from us by the natural content of the earth's atmosphere. Actually, there are a large number of such extra-terrestrial phenomena that are of interest to us. By using a spiraling electric rocket, we could drop off twenty or thirty small spacecraft monitors at varying orbits and obtain constant 'space weather' information with relative ease, low cost and in less time."

We had both finished our drinks and, when the subject of time came up, I suggested we leave. It's a three hour drive to Pasadena.

"Absolutely right. Long day tomorrow. Wait a minute though."

He got up from our table and went over to the girl. Within a few seconds they were involved in a rather animated conversation which I had difficulty overhearing. I did catch one remark Merton-Smith made, however.

"I own a little bull ranch just outside Barcelona."

E O S

Dr. Burton Merton-Smith will be happy to exchange resumes with you. You send yours to him. He'll send his to you. Fields of interest: energy conversion, space propulsion, space probes, laser technology, imaging devices, optical systems and instruments, and information handling. EOS is an equal opportunity employer.

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Technical Countdown

MATERIALS

Vacuum Cold Welding May Go Commercial

Metal parts have been cleaned and cold-welded in vacuum chambers at National Research Corp. in studies that may develop into a commercial process for joining microminiature electronic circuit components. The cleaning was accomplished with a simple wire brush and time limits were established for the cleaning to permit bonding. The advantage of cold-welding in such manufacturing operations is that the joining of the metals would be accomplished without contamination or weakening of the joined structure. The experiments also confirmed earlier assumptions that soft metals tend to cold-weld much more easily than the harder metals. The work was funded by NASA's Office of Advanced Research and Technology—prompted by a concern for such cold-welding effects on long-term space missions. The problems of cold-welding in space have not been solved, but the phenomenon may have its beneficial aspects—as in fabricating structures on the Moon or in space.

Metal Blistering in Space Studied

Investigations into the blistering effect of particle radiation on metal surfaces at Avco/Tulsa will continue under a $60,977 contract extension with NASA. Aluminum samples irradiated in previous research at Avco gave evidence of such surface changes. Proton radiation seems to be the main cause. When the protons strike the aluminum they penetrate to various depths and then begin to behave like hydrogen gas. The protons collect at various locations, causing bubbles in the structure of the metal. If the gas pressure becomes great enough, or if the metal is heated—as in space—the small gas bubbles expand. One current theory is that the blisters are formed because the hydrogen gas cannot push through the tough aluminum oxide coating.

Goddard Paints Show Commercial Promise

A series of spacecraft paints developed by researchers at NASA's Goddard Space Flight Center adhere to most metals and many non-metals such as glass fiber laminates and cellulose materials. The inorganic paints will not crack, blister, chalk or peel when subjected to temperature ranges from —320° to 1,800° F. In addition, the paints are washable, can be made in any color and have a long shelf life. The compounds use an alkali metal silicate as a binder and any one of a variety of inorganic phosphates as wetting agents. The paints were originally developed for spacecraft coatings. Aluminum oxide is used as the pigment and filler, which gives the paints high stability under the ultraviolet conditions of space. Most of the paints do not have to be baked on a surface but cure at room temperatures.

Dry Ice Feasible for Spacecraft Insulation

Research at General Dynamics/Convair indicates dry ice can be used to insulate hydrogen-powered vehicles. In an insulation concept outlined by John Clay of Convair at the recent Society of Aerospace Materials and Processes Engineers National Meeting, the hydrogen fuel itself could be used to produce the dry ice. Carbon dioxide could be pumped into a quilt-like quartz material enclosing the spacecraft and filled with helium gas. The cold from the liquid hydrogen fuel would freeze the CO_2 to dry ice. As heat builds up around the vehicle in flight, the dry ice would sublime away through hull vents, removing the heat and protecting the thermal environment in the hydrogen fuel tanks. The dry ice idea was conceived by scientists at NASA's Langley Research Center. Convair is under contract with NASA to investigate the insulative properties of the material.

Metals Vaporization Data Compiled

Scientists at the National Bureau of Standards have developed a non-classical method of determining the heats of vaporization of high-temperature metals. The data gathered from the new technique will provide a comparison with information derived from more classical methods. The surface ionization method, perfected by M. D. Scheer and Joseph Fine of the NBS Institute for Basic Standards, bombards the heated metal surface with alkali halide molecules. The data obtained on the surface ionization of the halide are used to compute the work function of the metal. The heat of sublimation is then obtained from the temperature dependence of the self-surface ionization of the metal. Niobium is being studied with the technique, and work on other refractory metals is planned. The data will be helpful in re-entry studies and high-speed travel in the Earth's outer atmosphere.

New Hi-Temp Insulation Developed

An alumina-silicate-chromia fibrous insulation with three to five times the resistance to shrinkage at high temperatures as alumina or silica is being marketed by Johns-Manville. Recommended for long-term applications at soaking heats to 2,700° F, the material retains its fibrous form and can be used for one-time transient exposures well above the 2,700° F level. Designated Dyna-Flex, the material showed only a 3.7% shrinkage after four hours at 2,700° F —compared to 15.4% for alumina silica. Thermal conductivity of the material is similar to or better than alumina silica felted fibers. Currently available in 14 x 16-in. blankets of 8 pcf density, in thicknesses from 0.25 to 2.0 in., a complete range of sizes, thicknesses and densities will soon be on the market.

PROPULSION

Lockheed Activates New Nitroplastisol Facility

Lockheed Propulsion Co.'s Nitroplastisol composite double-base propellant is being manufactured in 1,400-lb. batches on a new, lightweight mixing line at the firm's Redlands, Calif. facility. Low-cost fuel slurry master batches are prepared with a low-power turbine blade mixer. After addition of specified solids, such as ammonium perchlorate and metal powders, the final mixing takes place in a specially designed 85-gallon vertical, double planetary Ross mixer. Portable, packeted change cans are used to keep the process essentially continuous. The Lockheed process allows light construction in the mixers and generous clearances. The open-square blade design achieves efficient stirring of the whole batch without splashing or heavy shear loads on the mixer. In six years of research and pilot operations with high-energy propellants, the Lockheed plant maintains a perfect safety record.

Firm Matches Computers with Jobs

SCERT technique employs computers to evaluate other computers for particular applications; issues reports covering cost, time and manpower requirements

by John F. Judge

THE FIRST ACCURATE and reliable systems technique designed to evaluate computers for particular data processing problems is rapidly gaining acceptance.

The technique, developed and perfected by Comress, Inc., Washington, D.C.—and sold as a service—is presently in use by computer manufacturers themselves.

The method, designated the Systems and Computers Evaluation and Review Technique (SCERT) is a series of proprietary programs designed to simulate the performance of individual program runs against any configuration of commercially available computer equipment within the U.S. It is only applicable to digital systems.

The SCERT program uses computers in the process and its "product" is a series of management reports covering analytical projections of cost, time, memory and manpower requirements necessary to put a client's data processing system in operation on any one of the computers evaluated.

It is a management tool and does not decide for the client. The reports accurately define the number and kinds of alternatives open to the Comress customer in his selection of a data processing system suited to his particular needs.

The technique can even provide a pictorial representation of the system simulated in flow chart fashion.

● **Perpetual up-dating**—Comress, Inc., was founded about 30 months ago by its president, Donald J. Herman, and several highly expert computer people after the development of the SCERT technique. The technique itself is constantly being validated through usage and draws on a library of commercial computer information, which includes all units being manufactured in the U.S.

The library has hardware and software factors covering both the central processors and related peripheral devices. New computers brought on the market by manufacturers are introduced to the library within about 30 days.

Segments of the banking, equipment-manufacturing, utilities, retailing and manufacturing industries are clients of Comress. The state of California hired Comress to apply SCERT to its motor vehicle bureau as a preliminary to mechanizing the data handling task.

The Comress report to California was used as the request for proposals to computer manufacturers—with a resultant savings to both parties.

The firm really established itself two years ago during a major computer procurement by the Air Force. Herman sent registered letters to all the computer manufacturers bidding on the Air Force contract offering the services of Comress on a first-come, first-served only basis. Univac landed Comress.

Comress fed both the Univac equipment factors and the Air Force requirements into SCERT, generated the reports some two weeks later and Univac, using the information, won the contract.

● **Not restricted to selection**—SCERT is not limited to hardware selection. It can function equally well in hardware enhancement and replacement tasks, application analysis, installation reviews and hardware design.

Some aerospace firms are using SCERT in preparing proposals for upcoming major weapons system procurement. In this, as in certain other areas, Comress will accept only one client. These areas would be similar to the Univac situation.

Comress does not own a computer. Herman and his associates prefer to rent time on units during the SCERT exercise. Herman leases SCERT services on a monthly or annual basis, depending on the customer's requirements. SCERT remains the property of Comress at all times.

Herman says computers are really only management tools and Comress, through SCERT, provides a greater breadth of management ability in applying computers to the particulars of any firm's business. One of the prime reasons SCERT is effective is in its ability to relate a client's problem and environment to those computer configurations he either has, or is considering leasing or purchasing.

The size and complexity of SCERT is best illustrated by the 31,000 instructions that can be used to build mathematical models of various data processing problems.

The package contains approximately 5,000 algorithims and draws on the continuously current library of over 100,000 hardware and software factors.

The ability to define runs to SCERT is explained by Herman as a range of magnitude rather than an average time. This range has varied from a minimum of 10 to a high of 50 runs and their associated files defined in one man-day.

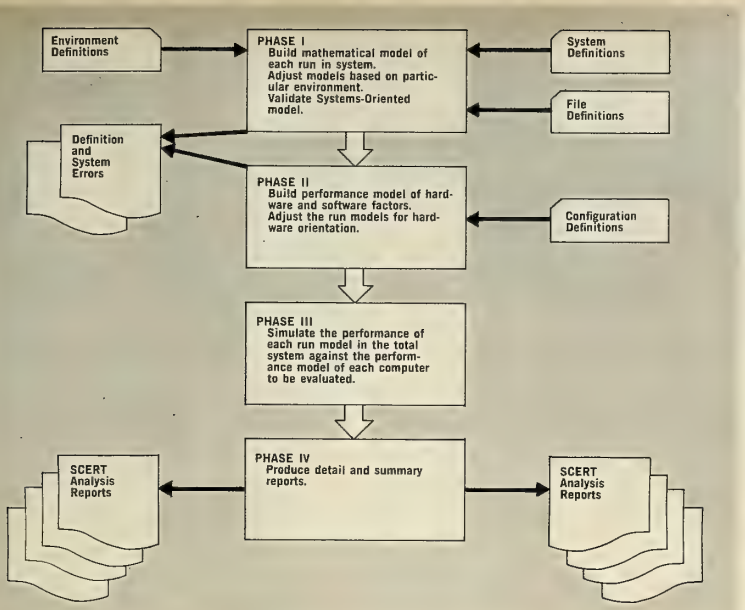
The typical average job handled by Comress for the complete production of a SCERT analysis is about four weeks. The time required for definition is usually a function of the condition of documentation or the availability of the time of the systems analysts designing the simulated systems—or both.

SCERT is a four-phase program. Phase I builds mathematical models of the systems being examined and assures that these are systems-oriented. Phase II adjusts these models to the type of machines under evaluation. Phase III simulates the performance of these models on each of the configurations under evaluation, and Phase IV provides the decision data on the several output reports that comprise the actual Comress product to the customer.

● **SCERT description**—In the first phase, the model is built on systems, environment and files definitions. The systems definitions are verbal portrayals reflecting frequency, occurrence, number and identity of the input/output files together with the type of computer activity.

There are ways to describe activities in this area—covering any type of activity in six basic verbs. These are updating, sorting, merging, sequence memory, validation and extraction. This phase covers everything any computer can do—moving, comparing, editing, translating, adding, subtracting, dividing and multiplying data.

The file definitions reflect the basic parameters of each file including data


Environment Definitions
PHASE I
Build mathematical model of each run in system.
Adjust models based on particular environment.
Validate Systems-Oriented model.
System Definitions
File Definitions
Definition and System Errors
PHASE II
Build performance model of hardware and software factors.
Adjust the run models for hardware orientation.
Configuration Definitions
PHASE III
Simulate the performance of each run model in the total system against the performance model of each computer to be evaluated.
PHASE IV
Produce detail and summary reports.
SCERT Analysis Reports
SCERT Analysis Reports

SCHEMATIC OF Comress, Inc.'s SCERT Program.

such as number of records, number of characters/record, number of alpha and numeric fields and the category and data media of the file.

Environmental definitions cover necessary factors or factor adjustments for all functions based on pure judgment. This input phase of SCERT is an open-end design to allow for the individual requirements of each user.

Softwear, hardware and general environment factors are included. Within this section of Phase I, the experience level of the user's programming staff is mathematically related to the complexity of the systems application and the programming difficulty of the language to be used for the configuration under evaluation.

The second phase of SCERT accepts these models which inherently define each of the computer configurations to be evaluated. Based on these definitions, hardware and software factors are extracted from the SCERT library.

● **Building the simulation**—SCERT then arrays these factors in the form of a three-dimensional matrix and modifies the mathematical models of the runs in the system to conform to the hardware requirements of the particular computer.

During both of these initial phases, SCERT performs a complete validation of all input definitions, checks for proper coding and its consistency.

The systems application is continuously checked to insure its validity—especially in terms of the computer configurations under evaluation.

For example, SCERT will determine if sufficient peripheral devices are available and are the right kind to handle all input and output functions. Errors discovered by SCERT in performing these validations are printed and the user has the option of continuing or restarting.

The simulation of the performance of each computer run model to be evaluated is the basis for most of the decision theory techniques incorporated into the SCERT program. Herman says this simulation technique can best be described as the explosion of the computer run to its maximum number of thruput iterations.

SCERT contains over 5,000 algorithims used to perform this simulation in the third phase. Initially, all input, ouput and internal computation times are calculated. As these timing forecasts are developed, a preliminary assignment of these times is made based on the powers and features of the central processing unit.

Then, based on the simulation of the thru-put iterations, the simultaneous and net times are derived for each run.

SCERT also computes the number of program steps, amount of memory used, and number of tapes required as a by-product of this simulation.

In addition, a pre- and post-run history is developed to forecast the utilization of peripheral equipment such as key-punch, off-line card reading, satellite computer time and other requirements.

● **Basis for decision**—The fourth phase of SCERT is the product phase. This is where the reports are generated —providing the customer with a comprehensive range of detailed and summary management information. These are not judgments—only compilations of data based on the simulated runs, which in turn are created by the particular requirements of the customer.

The report series includes:

—*Computer Complement Report*—This provides for each computer complement evaluated and reflects, by hardware types, the quantity of each model number in the configuration, purchase price, minimum monthly rental and the environmental requirements of flooring, cooling and power.

—*Central Processor Utilization Report*—This is a summary by program run of the SCERT forecast covering program running, set-up/take-down time and memory utilization. There is also information for those applicable computer systems on the parallel data conversion that could be scheduled during each program run. This includes average use time and peak period use.

—*Satellite Computer and Auxiliary Equipment Utilization Report*—This particular product considers the pre- and post-run history development elements of SCERT and forecasts the satellite and auxiliary equipment utilization for each computer run in the system. Breakdowns are by equipment function and data preparation time.

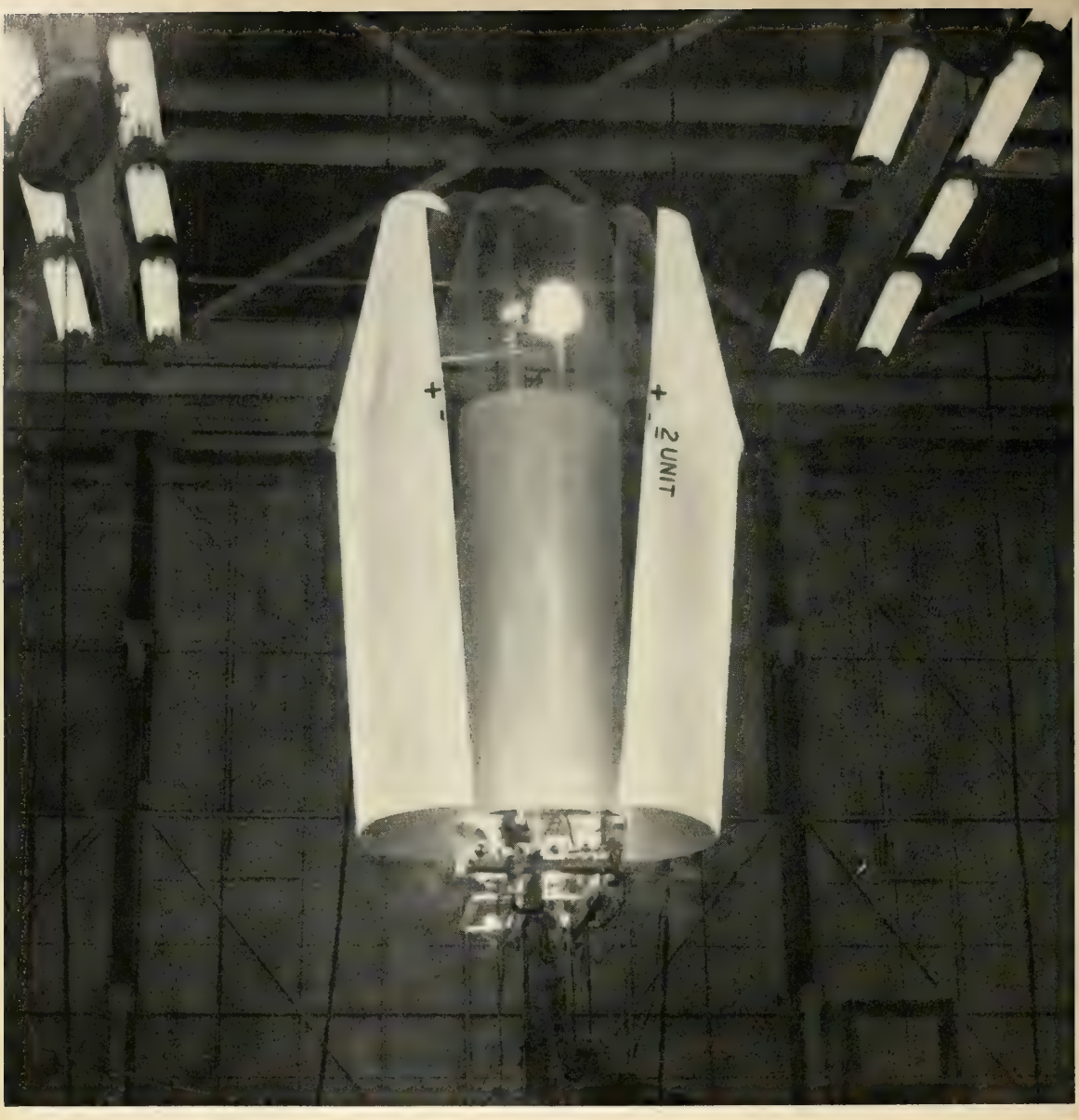
—*Programming Requirements Report*—This computation is made with respect to the experience of the customer's programming staff correlated to the programming difficulty of the specific computer involved and the nature of the programming run. The report is also a recap by individual program run and projects the number of program steps needed to activate the entire process. Then there is an estimate of the user's programming effort in man-months.

The report reflects the number of program steps saved by using applicable sub-routines and utility programs furnished by the individual computer manufacturers.

—*Application Summary Report*—All of the program runs are summarized within each application area to assist the user in determining priorities. The monthly system utilization by application is shown together with a projection of programming effort and associated cost.

—*Cost Summary Report*—This item is a management digest of the costs associated with installing the computer and operating it once all applications are programmed. Recurrent costs are also analyzed, as are renting and purchasing comparisons. The latter are optimized.

There is a last report, termed optional by Comress, which provides a comprehensive analysis of each computer run as simulated by SCERT. ■



New way to peel a payload

New from Douglas is a revolutionary advance in shroud separation systems. The Douglas system, which was two years in development, meets the latest spacecraft requirements for shroud separation without contamination of payload.

Other important advantages over previous systems include reduced shock level, increased separation velocity, reduced weight and greater reliability. Fragmentation and smoke have been eliminated. Shaped charges are not used.

Get full information on this important new technological improvement in shroud separation systems. Write to Mr. J. N. Glover, Special Space Systems, DOUGLAS, 3000 Ocean Park Boulevard, Santa Monica, California.

DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION

Nitehawk Provides Reliability at Low Cost

Sandia-developed Nike-Tomahawk hybrid has made 40 successful flights since June, 1963; has investigated nuclear weapon debris, extra-atmospheric coning

by Rex Pay

THE *NITEHAWK 9* sounding rocket is now a fully developed operational system that has proved to be highly reliable and low in price.

It can carry 40-60 lbs. of instruments in a 9-in.-dia. payload to altitudes of 200 mi. A 12-in. version that will loft 200-250 lbs. to a similar altitude is in the "request for proposals" stage.

Cost of a flight-ready two-stage solid-propellant *Nitehawk 9*, with motors, telemetry, and recovery package is about $24,620. An attitude-control system to point a payload to within ±3 degrees of a selected direction in inertial space costs about $20,000.

Two major achievements in the *Nitehawk's* development program have been the successful flight of a device for sampling nuclear weapon debris and micrometeorites above 250,000 ft., and the extensive investigation of extra-atmospheric coning motion.

This motion appears in telemetry as pitch and yaw oscillations that can grow to ±30 degrees or more, with a period of 20 to 50 sec. Because of its low energy, coning of this size has been rarely recognized by previous vehicles. But analysis of records shows that it has been present and has caused previously unexplained instrument errors.

● **A hybrid**—The present *Nitehawk 9* is a spin-stabilized vehicle made up of a *Nike M-5/Tomahawk TE-416* combination. It was developed by Sandia Corp. to meet an Atomic Energy Commission requirement to carry gross payloads of 125 lbs. to altitudes above 950,000 ft. with the greatest possible operational flexibility.

First flights with the vehicle started in June, 1963. Apart from spin-yaw coupling on two early flights and one faulty ignition of the second-stage motor because of an unpotted squib, all 40 flights flown by Sandia to date are said to have been successful.

The AEC originally specified that payload orientation had to be predictable to within ±5 degrees. Sandia's experience has shown, however, that without an attitude-control system, one in four flights can be expected to develop a coning motion that exceeds this. Fortunately, a re-survey of the instruments to be flown indicates that 95% will not be affected by extra-atmospheric coning.

PLEXIGLAS MODEL of Nitehawk 9 payload section. Compartment at upper end of vehicle is for instrumentation. Space above squib-firing package (bottom) is for recovery system.

A new single-nozzle attitude-control system that was flown operationally for the first time on *Nitehawks* during the May 31 solar eclipse damps out the coning motion in about 5 seconds.

Sandia's description of the instrumentation carried by the *Nitehawk* for the AEC is that it is diagnostic equipment for getting "a variety of information on winds, radiation, and solar activity at heights up to 200 mi."

Emphasis in the early flights was given to soft X-ray measurements of the Sun, aurora photography, and to testing the upper atmosphere sampling device.

Thiokol Astromet Div., producers of the 12-ft.-long, 9-in.-dia. *Tomahawk*, reports that 56 *Tomahawks* have been flown, 13 as single stages. As second stage for the *Nitehawk*, the *Tomahawk* reaches Mach 8.5, which makes it probably the fastest sounding rocket in use today. This speed enables it to punch through high-altitude jet streams with very little lateral deflection. The *Nike* 12 is expected to reach Mach 11.

● **Simplicity maintained**—William C. Womak, *Nitehawk* project manager at Sandia, reports that the launching procedure is simple and the turn-around time short. "We give the booster to almost any crew," said Womak, "and they do not have any problems launching it." A simple rail launcher about 16 ft. long is used.

As evidence of the ease with which a *Nitehawk* system can be installed, four launchers have been put down in a coconut patch on Rarotonga in the Cook Islands. This enabled simultaneous launch of four rockets during the May 31 solar eclipse. Sandia previously fired the *Nitehawk* from its launching site on Kauai. Other firings have been made from Wallops Island, Va., and from Fort Churchill, Canada.

Production of flight hardware for

When LEM men go down to the moon in ships.

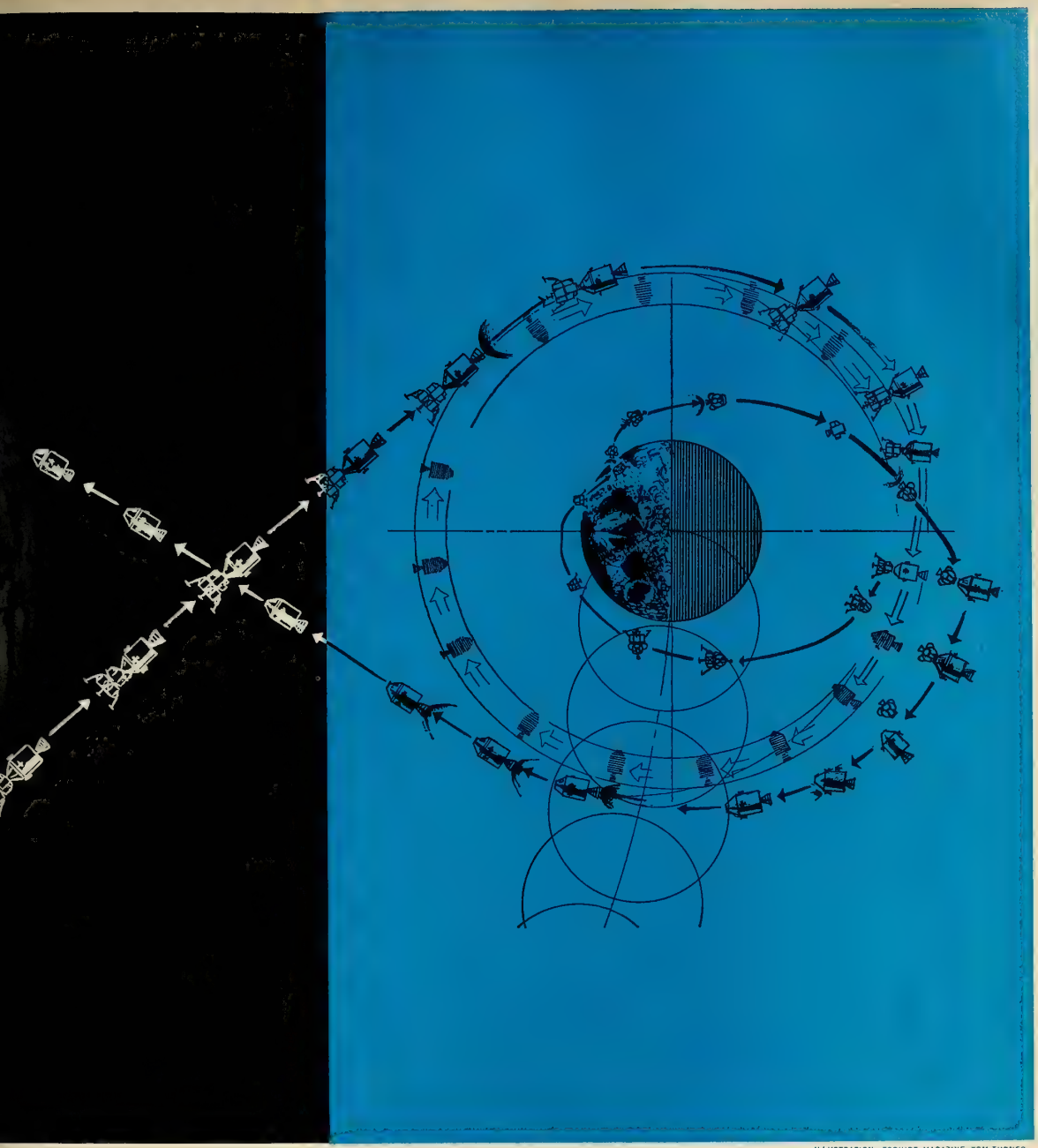


ILLUSTRATION: ESQUIRE MAGAZINE, TOM TURNER

TRW will help them get back. By 1970 two Apollonauts will descend onto the moon in their Lunar Excursion Module (LEM). A TRW advanced propulsion system will land them feather-soft. They will explore the lunar surface, then prepare for the long journey home. After lunar blast-off they will rendezvous with their return vehicle holding in orbit 80 miles out. During this lunar phase a lightweight TRW-built "strapdown" inertial guidance system will enhance their safety. These major Apollo tasks have been assigned to TRW Space Technology Laboratories by the Grumman Aircraft Engineering Corporation. TRW will also provide mission planning and analysis for Project Apollo, as it has done for the Mercury and Gemini programs.

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22-22-A

the *Nitehawk*, that is, the total payload forward of the *Tomahawk* head cap, has been carried out by Consolidated Systems Corp. The project manager there, Claus Sanger, says the chief aims in the design were to make use of reliable ordnance-type hardware and to produce a payload configuration that was easily and quickly serviced on the pad.

Sanger views the region above the 100,000 ft. altitude reached by balloons and below the 200 mi. traversed by satellites as a "big fat question mark." He believes many more experiments would be flown in this region if a cheap, reliable carrier were available. He believes the *Nitehawk* is such a carrier.

● **How it's stacked**—The flight hardware is made up of three main modules that fit together by means of breech locks. These carry multistart threads that mate when rotated 20 degrees. A module containing squib firing circuits is located above the *Tomahawk* head cap. The recovery module fits on top of this. Next is the telemetry system and then the instrument package. Ejection of the upper end of the nosecone can be carried out at altitude to expose instrument sensors.

Total payload weight is 150 lbs. When a recovery system is carried, 40 lbs. of instruments can be flown. Without recovery, 60 lbs of instruments can be flown.

First stage of the *Nitehawk* provides an average acceleration of 29 g over 3.5 seconds. The second stage coasts and then ignites 12 seconds from launch, developing an average of 26 g for 9 seconds. Vibration has been less than 5 g in the frequency range between 5 and 2,000 cps in all flights conducted by Sandia.

Recovery is initiated when the payload falls to 10,000 ft. A drogue chute is deployed by a pressure switch and the 6-ft. main chute emerges 10 sec. later. Flotation gear is provided.

Telemetry is carried by a 14-channel FM/FM transmitter that operates at ¼ watt in the 215-260 mc band, through two diametrically opposed zero-gain whip antennas. An AME/DME receiver is used in conjunction with the telemetering unit as a tracking device.

Telemetry from *Nitehawk* includes acceleration, vibration, and temperature data, and also spin and yaw information from an attitude-reference system employing a pair of two-degrees-of-freedom gyros mounted on a servo-controlled roll-stabilized platform. This is the Miniature Attitude Reference System (MARS) developed by Whittaker Corp.'s Guidance and Controls Div. in conjunction with Sandia.

Packaged in a unit 7.5 in. long by 5.0 inches dia., the MARS provides accurate attitude information in inertial coordinates while operating in a spinning vehicle.

● **Coning motion disclosed**—One result of flying this unit, along with the normal acceleration, vibration, and temperature diagnostic instruments, was the discovery of a large extra-atmospheric coning motion.

"If the attitude-reference system had not been flown, this motion would probably have escaped unnoticed," said Womak. However, once its presence was noticed, the signal strength of the received telemetry record was recognized as being quite different for coning and non-coning vehicles.

This led to a re-examination of telemetry from other sounding rockets with high fineness ratios, such as the *Nike-Cajun* and *Nike-Apache*, and also three-stage systems. Extra-atmospheric coning was apparent and explained several baffling instrument problems in most cases. "Everything we have flown has shown this coning motion," said Womak.

The coning motion appears in one out of four *Nitehawk* flights. It is characterized by a low-frequency, 25 to 50-sec. period, and extremely low energy. Because of this, it would not be apparent in conventional ballistic instrumentation. When its effects have been noticed in the past, they have been blamed on gyro drift, or where magnetic sensors are involved, on fluctuations in the Earth's magnetic field.

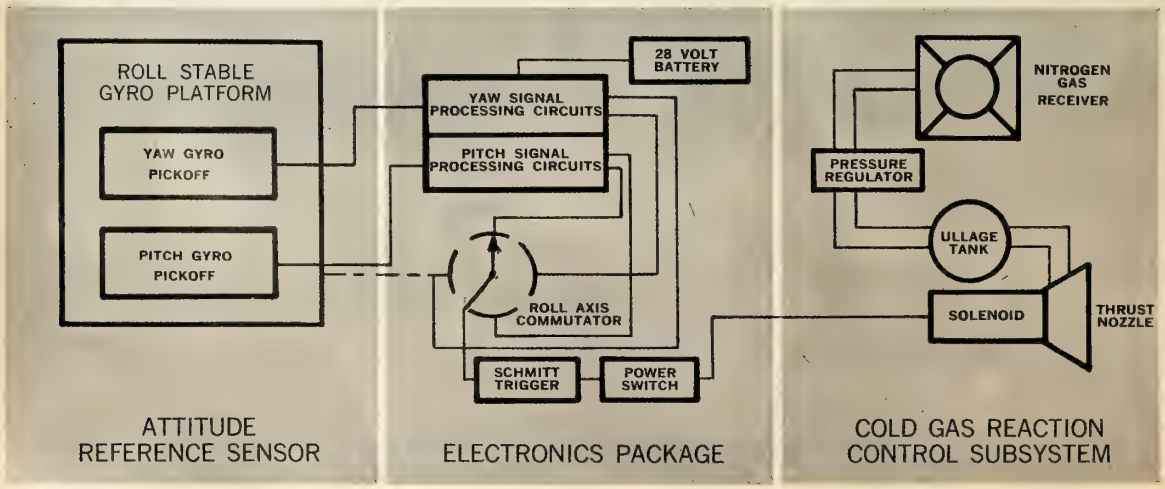
● **Payload stabilization**—To meet a requirement to stabilize the spinning payload along a prescribed direction in space, Whittaker has developed the Sandia D attitude-control system under Air Force and Sandia contracts. This makes use of the company's successful MARS system and a single-nozzle cold gas jet.

Use of this MARS as a basis for an attitude-control system developed from the TRUMP program at Eglin Air Force Base, Fla. Pitch and yaw information from MARS were used to control a single gas nozzle on a time-shared basis, as it rotated with the rocket's spin.

Sandia continued development of this concept, improving the packaging and going to dual potentiometer units in the sensor package to allow one outlet for telemetry and the other for the control system.

The most recent test flight of the attitude-control system on a *Nitehawk* was partially successful, but was marred by a pitch gyro disturbance that changed its inertial reference. Severe coning occurred with the half-angle reaching 40 degrees. The system damped out the coning in five seconds and aligned the instrument package in the correct plane

HEART OF THE Nitehawk 9 single-nozzle attitude-control system is the roll-axes commutator that turns with the spin of the vehicle, time-sharing the single nozzle between the pitch and yaw axis. Whittaker Corp. developed the system.



(to point at the Sun), but 23 degrees off in pitch.

However, the performance of the attitude-control system during this test and during spin-table tests at Sandia has been sufficiently encouraging for the system to be incorporated in the *Nitehawks* launched during the eclipse.

● **Attitude control**—According to Richard O. Rassmusen, engineering department, Whittaker Controls and Guidance, the key to the single-nozzle attitude-control system is use of a roll-axis commutator. This allows command signals from the pitch and yaw gyros to fire the nozzle only when it is pointing in the appropriate 60-degree sector. Because the nozzle reaction is applied to a spinning body, both acceleration and precession are produced. If, for example, there were no yaw error to start with, the approach to zero-pitch would be through a yaw error, which would then be nulled along with the pitch error.

A compact pneumatic unit for the attitude-control system is achieved by use of a toroidal reservoir to store the cold gas at 3,500 psi. A pressure regulator that cuts this to 65 psi is located within the toroid.

The complete attitude-control system, including MARS, electronics, pneumatics, and nozzle valve, weighs 21 lbs. The price is approximately $20,000 in quantities of about 10.

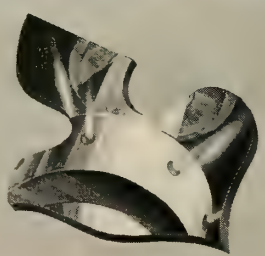
● **Particle sampler described**—Two successful flights have been made with the upper-atmosphere sampling device developed at Sandia and manufactured by Consolidated Systems Corp. It is an impingement type of collector made up of an 8-ft.-dia. sheet of 0.05-in. thick Mylar. This flattens out as a level disk in space because of the instrument package spin. It traps particles of 3-micron size and greater, being automatically rolled up and sealed before reentry.

Particle samplers have been plagued with problems, of which failure of the Luster flight (M/R, Nov. 23, 1964, p. 8) is one example. The Sandia sampler is therefore a significant development and will be important to the AEC for analyzing debris from Chinese nuclear weapons tests.

Its development work pre-dates *Nitehawk* and involved *Nike-Apache* shots. Main features of the design are absence of electronic or hydraulic systems and a simple timing mechanism.

One unexpected development problem occurred on recovery of the first *Nitehawk* shot with the sampler. When the sealed sampler capsule entered the Pacific, it sprung a leak, because of the hard vacuum it brought back from space. A decision was then made to use an inert gas to equalize capsule pressure. ■

Where do you fit in our picture?



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Optical Imaging Unit Shown Feasible

UAC system, using laser beam and acoustical beam deflection, holds promise as space-tracking, high-resolution radar

by Charles D. LaFond

AN ACTIVE optical imaging system employing a laser beam and acoustical beam deflection for scan and track has been developed and successfully operated in the laboratory.

Originally started in 1962 as an in-house project by the research laboratories of United Aircraft Corp., East Hartford, Conn., the effort has been supported through proof of feasibility during the past year by a Naval Bureau of Weapons $100,000 contract.

UAC's research labs served as prime R&D contractor and the firm's Norden Div. in Norwalk designed and developed much of the electro-optical subsystems for the demonstration model.

Under the recently completed contract, UAC:

—Developed an experimental ultrasonic deflection cell that provides scanning angles up to 1.5 degrees per inch of path length in the medium, and analyses indicate feasibility of obtaining deflection angles to 5 degrees/in.

—Developed a two-dimensional, high-speed optical beam-deflection system that is non-mechanical, electronically controllable and programmable.

—Developed and laboratory tested an active optical imaging system, using the deflection cell, that has produced high-quality target images from a test distance of 20 ft.

Upon completion of the BuWeps contract, the research labs continued in-house studies on the application of acoustical deflection cells to satellite tracking and underwater surveillance.

A $60,000 BuWeps follow-on contract, ending early in 1966, supports limited research for extending operating range of the laser imaging system.

Norden also has continued an in-house effort to further develop the imaging techniques for use in a terrain-avoidance optical-radar system.

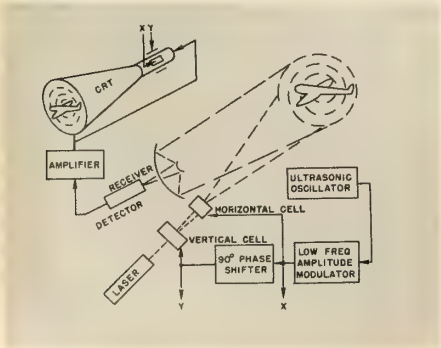
● **Attractive for space**—The recognition of objects through photographs or images and the measurements of temperature and distance by optical techniques are accepted practices.

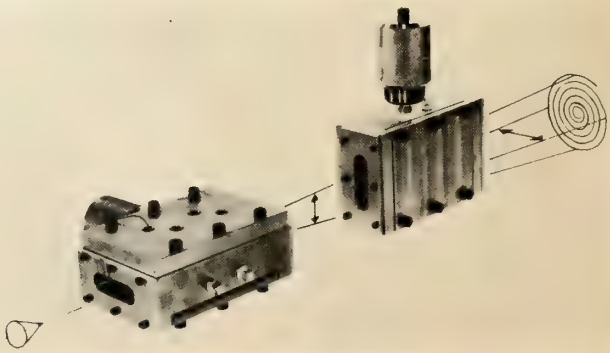
The advent of the laser added a needed stimulus to the field of optical instrumentation. The employment of lasers offers attractive possibilities for an optical radar, which would be potentially superior to a microwave radar in resolution capability because of the extremely narrow angular beamwidth possible at optical frequencies.

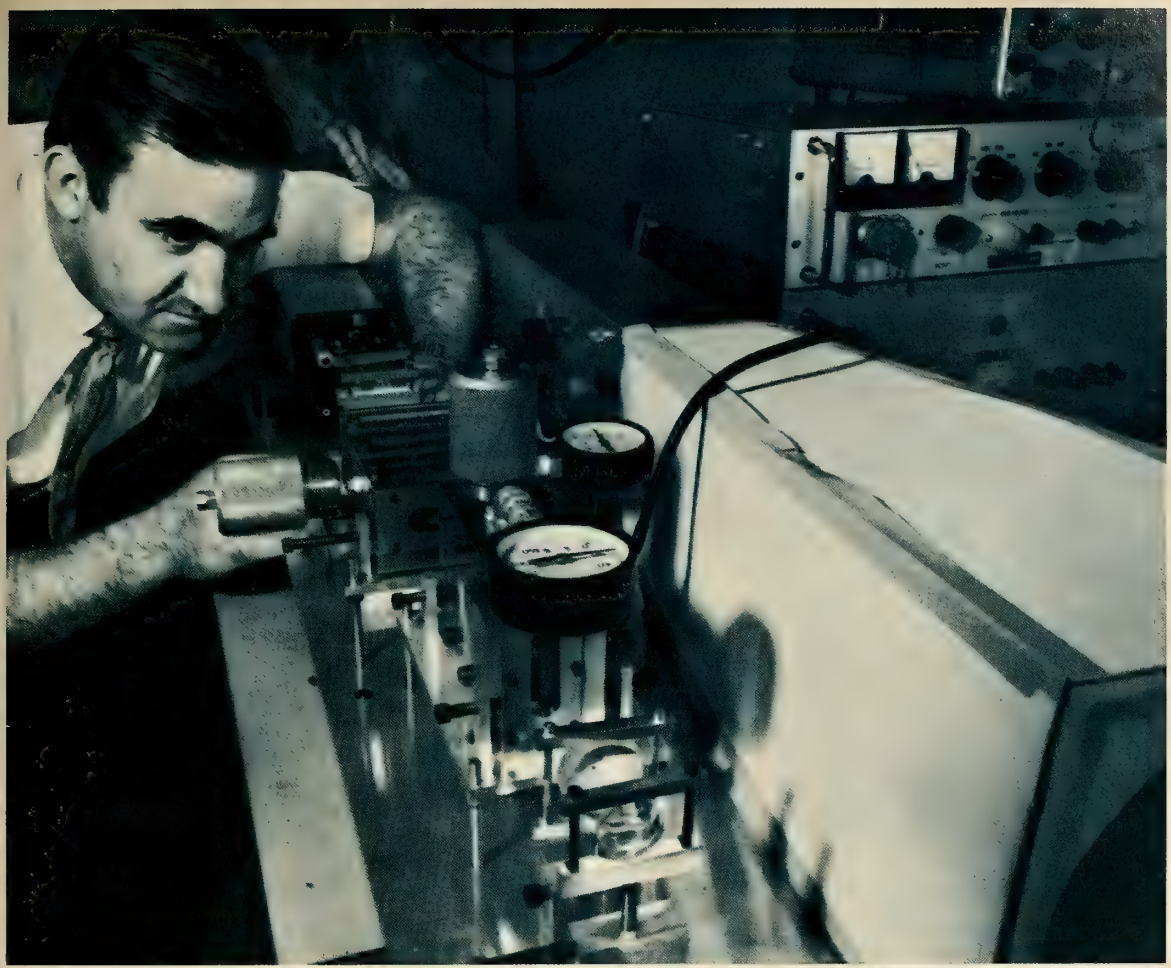
For example, a beamwidth of approximately 0.1 milliradian would be possible in the diffraction-limited case. This is approximately equivalent to the beamwidth provided by a 600-ft.-dia. paraboloidal-reflector antenna with Ku-band radar.

By supplementing an optical-ranging device with a scanning mechanism, search and identification are made available, and, conceptually, a high-resolution, active, optical imaging system can be envisioned for use in space docking and tracking applications.

LEFT: Ultrasonic light-scanning active optical imaging system showing transmitter illuminating a target. RIGHT: Two ultrasonic cells set up to systematically deflect laser beam in a spiral scanning pattern to produce two-dimensional area illumination.







TRANSMITTER-receiver portion of an active optical imaging system using acoustical beam-deflection techniques. Transmitter is at left, receiver at right in white housing. United Aircraft Corp. effort was funded in part by the Navy.

• **Acoustical cell**—A prime requirement of any active optical system, says Dr. E. C. Wingfield of the research labs, is a means to control the laser-beam direction accurately. One way to achieve such control is by making use of the principle that a light beam will be refracted in passing through a density gradient.

Investigations, he says, previously performed at the research labs indicate that an extremely promising technique for providing a suitable density gradient would be to establish an ultrasonic standing wave, thereby generating a time-varying material. In this manner, a time-varying refractive index gradient is created that will deflect a light beam back and forth at the ultrasonic driving frequency, if the beam is small in diameter relative to the sonic wavelength and is directed through a pressure nodal plane.

On this basis, theoretical and experimental investigations were undertaken by the labs into the optical and acoustical properties of various materials and ultrasonic transducers to develop an ultrasonic light-scanning cell.

The interaction of light beams and ultrasonic fields has been under study at the research labs for the past three years, with the most recent work carried out under the BuWeps contract. The analytical and experimental investigations carried out in the performance of the contract, Dr. Wingfield says, have successfully demonstrated that:

—Light beams can be non-mechanically deflected through angles in excess of 5° by establishing, ultrasonically, a time-varying refractive index gradient in a suitable medium;

—And, an active optical imaging system is practicable employing two ultrasonic deflection cells, which provide periodic two-dimensional field illumination.

• **Beam deflection**—The basic phys-

TABLE I

MATERIAL	REFRACTIVE INDEX	SONIC VELOCITY (cm/sec)	FREQUENCY (kc)	SONIC WAVE-LENGTH (cm)	PATH LENGTH (in)	DEFLECTION (degrees)
CRYSTALLINE QUARTZ	1.54	5.7×10^5	450	1.25	2.7	1.2
LUCITE	1.50	2.6×10^5	100	2.6	2.0	0.2
WATER	1.33	1.48×10^5	150	1.0	4.0	1.5
TETRACHLORO-ETHYLENE	1.50	1×10^5	120	0.83	4.0	2.2
			147	0.68	4.0	3.5
			326	0.3	4.0	6.0
TETRACHLORO-ETHYLENE MOSAIC DRIVER			100	1.0	3.2	2.0

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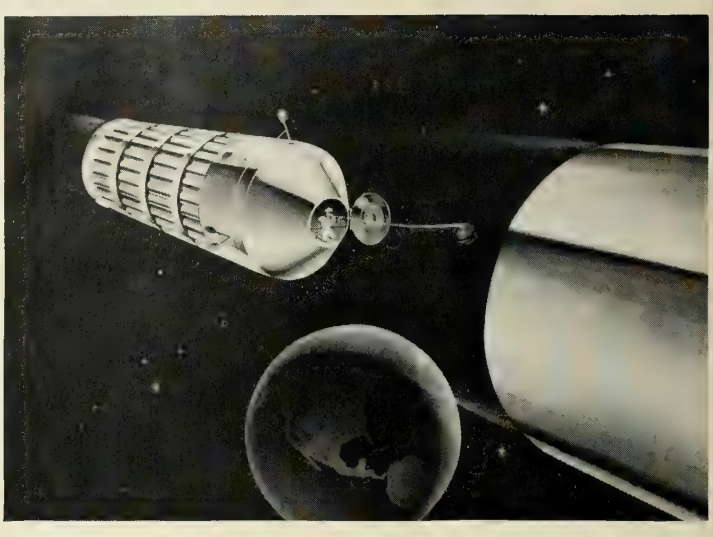

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Our Valley Forge Space Technology Center—with the most advanced, privately-owned space environment simulation facilities in the free world—gives us exceptional working tools to carry on our work on MOL. Our scientists and engineers are coming up with answers tagged "unrealistic" a few years ago in human factors, life support systems, communications systems, space power, navigation and control-rendezvous, and early escape from orbit.

Further into tomorrow, we have our eyes on larger, more complex and more heavily manned permanent space stations...space ferries to shuttle between earth, space station and other planets... and rescue ships.

If you're interested in learning more about openings on these many programs, write to Mr. J. S. Barson, Room 394F-1, Spacecraft Dept., Valley Forge Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia, Pa.

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LUBRICATION SPECIALIST

Chemical Engineer, Ph.D. or equivalent, with experience in lubrication, friction, and wear and an interest in solving practical lubrication problems encountered in airborne components. Understanding of spacecraft lubrication problems desirable but not mandatory.

GUIDANCE AND CONTROL SYSTEMS ENGINEERS

Conceive and conduct analytical studies resulting in the design and development of sophisticated systems for the navigation, guidance and control of Space Vehicles. Both active and passive techniques are currently under study and development for the control of Orbiting Spacecraft, rendezvous techniques, interplanetary flight and specialized military systems. Requires BSEE, ME or Physics. Intermediate and senior positions.

ENGINEERS — THERMODYNAMICS

Responsible for the design adequacy of orbital and re-entry space vehicles with respect to thermodynamics, heat transfer and aerodynamic heating factors. Will engage in synthesis and parametric studies pertaining to configuration heat protection system performances and internal cooling system performance. Requires MSME, AE or Chemical Engineering with 2 to 6 years' aerospace experience.

ENGINEERS — ORBIT DYNAMICS

Engage in earth orbit analysis, orbit determination, orbit prediction, statistical error analysis and interplanetary trajectory selection. Requires BSAE or ME with experience in celestial mechanics, orbit perturbation theory and Navigation and Guidance theory.

ENGINEERS — STRUCTURES

Perform structural loads and stress analysis on space vehicles and associated components. Support hardware design efforts, study programs and proposals. Requires minimum BS in Engineering with at least 4 years of applicable experience.

OPERATIONS ANALYSIS ENGINEERS

3 to 10 years' experience in space vehicle systems design, development, test and operations. Emphasis on hardware knowledge, systems integration and data analysis. Must be interested in responsible assignment and customer contact. Assignment is in technical support of military space programs.

PROJECT ENGINEERS

Responsible for technical direction of all work on assigned programs. This includes interpreting customer requirements, technical integration, establishing program direction and funding, and measurement of progress. Requires engineering degree, strong administrative capability and a thorough knowledge of engineering, manufacturing and quality control.

PhD — CONTINUUM MECHANICS

Theoretical studies of shock waves in solids, plastic wave propagation, and dynamic deformation and fracture of structures. Theoretical studies of the internal mechanics of composite materials including the effects of constituent geometry, inelastic and anisotropic constituents and thermal effects. Experimental and theoretical studies of constitutive relations and failure mechanisms for slow and very high strain rate effects in homogeneous, composite and layered materials and structures. Utilization of modern numerical methods for research in continuum mechanics.

ENGINEERS — COMMAND & TELEMETRY DESIGN

Responsible for the design of new spacecraft components from conceptual phase through detailed design, production, test and use. Includes airborne and ground telemetry, voice and video circuitry and sensor components. Requires comprehension of analog and digital circuitry, receiver and transmitter design experience and a knowledge of microelectronics. BS/MSEE or Physics with minimum of 4 years experience.

ENGINEERS — MILITARY SYSTEMS

Plan, direct and contribute to studies of advanced Military Space Systems by means of synthesis and design principles leading to the establishment of satellite vehicle system definition. Emphasis is placed on working systems knowledge in the field of Spacecraft Communications, Guidance and Control and Information Systems. Individuals will contribute to preproposal, proposal and contract studies. Requires MS in Systems Engineering, Physics or EE and minimum of 7 years applicable experience.

SYSTEMS ANALYSIS ENGINEERS

Interpret satellite systems design and operational mission requirements. Identify and analyze performance parameters and assess their influence on the vehicle system. Perform design trade-off analyses and prescribe acceptable systems behavior, operating domains, tolerances and performance variations. Develop the analytical facility to implement systems synthesis and optimization and evaluate development progress, malfunction, reliability, effectiveness, vulnerability and capability of the vehicle systems. Requires BS/MS EE, ME or Physics and broad understanding of missile/spacecraft subsystems.

ELECTRICAL SUBSYSTEMS ENGINEERS

Responsible for the design, development testing and qualification of the assigned Spacecraft Electrical Subsystem, including all components. Emphasis is on airborne control for the electrical distribution in a space vehicle, including electrical power and signal distribution for AGE. Requires BSEE with minimum of 4 years' applicable experience.

INFRARED AND OPTICS SPECIALIST

Responsible for originating, integrating and presenting technical studies of a systems analysis nature. Plan and direct experimental programs to validate new systems and subsystems concepts. Interpret the tactical and strategic technical requirements of the customer in the IR/Optical area and translate these into relationships that can be used for synthesis of AICBM systems. Requires MS/PhD in Physics and broad systems experience in IR and/or optics instrumentation.

RELIABILITY ENGINEERS

Individuals will be responsible for determining reliability requirements on assigned programs, to include: design, reliability; failure mode and effects; system and component analysis; test design and evaluation; failure analysis; maintainability; risk assessment; cost analysis and vendor reliability. Requires BSEE or Physics and 3 to 5 years' applicable experience.

PRODUCIBILITY ENGINEERS

Work directly with design engineering to establish manufacturing feasibility of structural, electrical, and electronic design concepts. Will act as manufacturing engineering liaison man to design engineering in the resolution of problems in the production area. Requires ME or EE with 6 to 8 years' combined engineering and manufacturing experience.

NUCLEAR SYSTEMS ENGINEERS

To perform analytical studies of advanced nuclear spacecraft, with emphasis on power plant-vehicle integration problems, system "trade-off" analyses and optimization, analysis of low-thrust propulsion requirements and trajectories. An MS degree in mechanical or aero engineering is preferable. Experience need not be in nuclear area, but the incumbent should possess broad capabilities for systems analysis work and be familiar with the use of large scale computers. A recent MS graduate would be considered for this position. The incumbent will work directly with an experienced project engineer and would learn the various nuclear spacecraft technologies "on the job."

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TABLE II

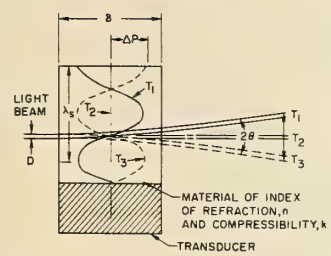
SYSTEM	LINE RESOLUTION	FRAME RATE (cps)	FIGURE OF MERIT
LASER IMAGING SYSTEM	115 x 115	50	6.6×10^5
TYPICAL RADAR SYSTEM	120 x 120	1	1.44×10^4
TYPICAL TV SYSTEM	350 x 320	30	35.6×10^5

ical principle on which the optical-beam scanning cell operates is that a light beam, in passing through a density gradient normal to the direction of light propagation, will be bent toward the region of higher density. Thus, says Wingfield, by setting up an ultrasonic standing wave in a refractive medium, a time-varying sinusoidal density gradient will be established that will alternately refract a light beam, passing through a pressure nodal plane, to either side (see accompanying schematic).

The angular deflection, which is produced on the light beam in traversing a sonic field, is directly proportional to the path length in the field, the acoustic pressure variation, the compressibility of the material and an optical index of refraction term, and is inversely proportional to the sonic wavelength.

• **Cell material studies**—To date, crystalline quartz, lucite, water and tetrachloroethylene ultrasonic optical beam scanning cells have been investigated with particular attention being given to the optical index and sonic wavelength (function of ultrasonic frequency) parameters. (See Table I for summary of results.)

SCHEMATIC representation of an ultrasonic scanning cell.



$$\theta = \delta(2\pi/\lambda)(k/6n)(n^2-1)(n^2+2)\Delta P$$

LEGEND

- Θ Angular deflection of beam.
- δ Path length (in the field).
- ΔP Acoustical pressure variation.
- K Compressibility of material.
- λ_s Sonic wavelength.

Optical index of refraction

$$\left[\frac{(n^2-1)\quad(n^2-2)}{6n}\right]$$

A two-dimensional scan can be produced by employing two deflection cells, one for the horizontal and one for the vertical direction. Each cell produces a spot of light that moves with simple harmonic motion; thus, if both cells are driven by the same frequency but with a 90-degree phase shift between them, a circular scan can be generated.

The scan, Wingfield points out, can then be made to spiral by modulating the driving power (amplitude of the sonic wave). This in turn modulates the radius of the circle at a lower frequency than the ultrasonic frequency and thereby provides two-dimensional area coverage.

Norden fabricated a demonstrational model of an active optical imaging system employing tetrachoroethylene cells developed at the research labs. The ultrasonic deflection cells in the laboratory model are being driven at approximately 150 kc with sufficient power to provide circular field coverage of 2.5° to 3° angular extent.

The reflected radiation from any target placed within the illuminated cone is focused on a photomultiplier, amplified, and used to modulate the z-axis of a cathode ray tube. The x- and y-deflection plates of the CRT are driven in synchronization with the ultrasonic-deflection cells; an image of the scanned target is thus produced on the face of the cathode ray tube.

• **Search and track**—Field expansion optics can be employed to increase the deflection angle of the beam as it emerges from the ultrasonic cells. In the experimental system, a small two-power inverse telescope was inserted while holding the deflection angle and target distance constant, thereby effectively increasing the field coverage. The total number of resolution lines across the field remained the same.

The two-power optics were later replaced with a four-power field-expansion optical system. Again the total number of resolution lines remained the same. Success in significantly broadening the field of view, said Wingfield, suggests the possibility of a search-track system in which the field-expansion optics are employed in the search mode and field-reduction optics are employed for high-resolution identification and tracking once a potential target has been located.

The technique of bending a light beam by ultrasonic waves, according to UAC, has the advantage of a controllable, high-frequency electronic scan. The fact that there are no moving parts and that the scan mode can be adjusted electronically provides great reliability and versatility to the system, the firm claims.

A useful parameter for comparing this spiral laser optical imaging system with typical radar and television systems is a figure of merit defined by UAC engineers as the product of the total number of resolution elements in the field and the frame frequency. Merit (M) then is the number of resolution elements per unit time. A comparison of this figure of merit for the three systems, drawn by UAC research labs, is shown in Table II.

It would appear from these data that the laser-imaging and TV systems have competitive data-gathering rates and that the figure of merit of the laser imaging system is much higher than can be achieved with radar systems. UAC points out that the framing rate employed in the laser imaging system is independent of the ultrasonic scanning frequency and thus conceivably could be as high as 1 kc, yielding a figure of merit of 1.32×10^7.

• **Future applications**—In addition to the laser active optical imaging and search-track applications, many other uses of an ultrasonic optical beam-deflection system may be considered, Wingfield says.

An ultrasonic scanning technique offers the unique capability of providing a non-mechanical optical scan that may be electronically controlled and programmed at video rates. Advantages of the sonic scan, relative to conventional radar and mechanical scans, include increased resolution, speed and accuracy. Additionally, it operates at much lower voltage levels than most comparable beam-deflection devices that are now being utilized or considered.

In the form of an optical imaging system, areas of useful application include: flying-spot scanner, high-brightness CRT-type display, pattern recognition, computer data display and readout, and high-resolution mapping, surveillance and target recognition.

With the addition of a ranging capability, which may be simultaneous with the imaging function, other potential areas of application include: ranging with or without simultaneous imaging (air-ground, ground-air, etc.), terrain clearance for low-altitude aircraft, altimetry, semi-active missile guidance, rendezvous and docking for space requirements (greater accuracy plus simultaneous imaging of closing vehicles with controllable field of view), and ground-air target tracking. ■

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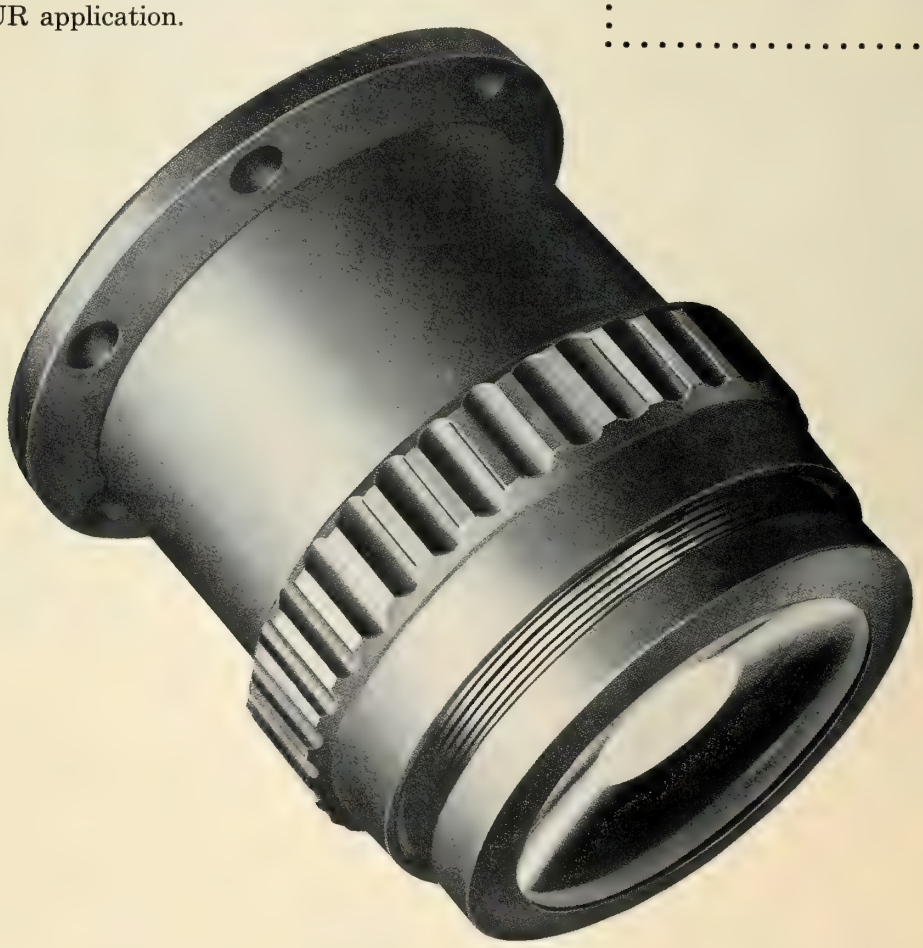

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Flag rank officers, nuclear submarine crews use attack center trainers to test tactics at New London installation

U.S. NAVY nuclear submarine crews and flag rank Naval officers are being trained in all phases of offensive and defensive tactics in the newly completed attack center trainer at the Naval Submarine School, New London, Conn.

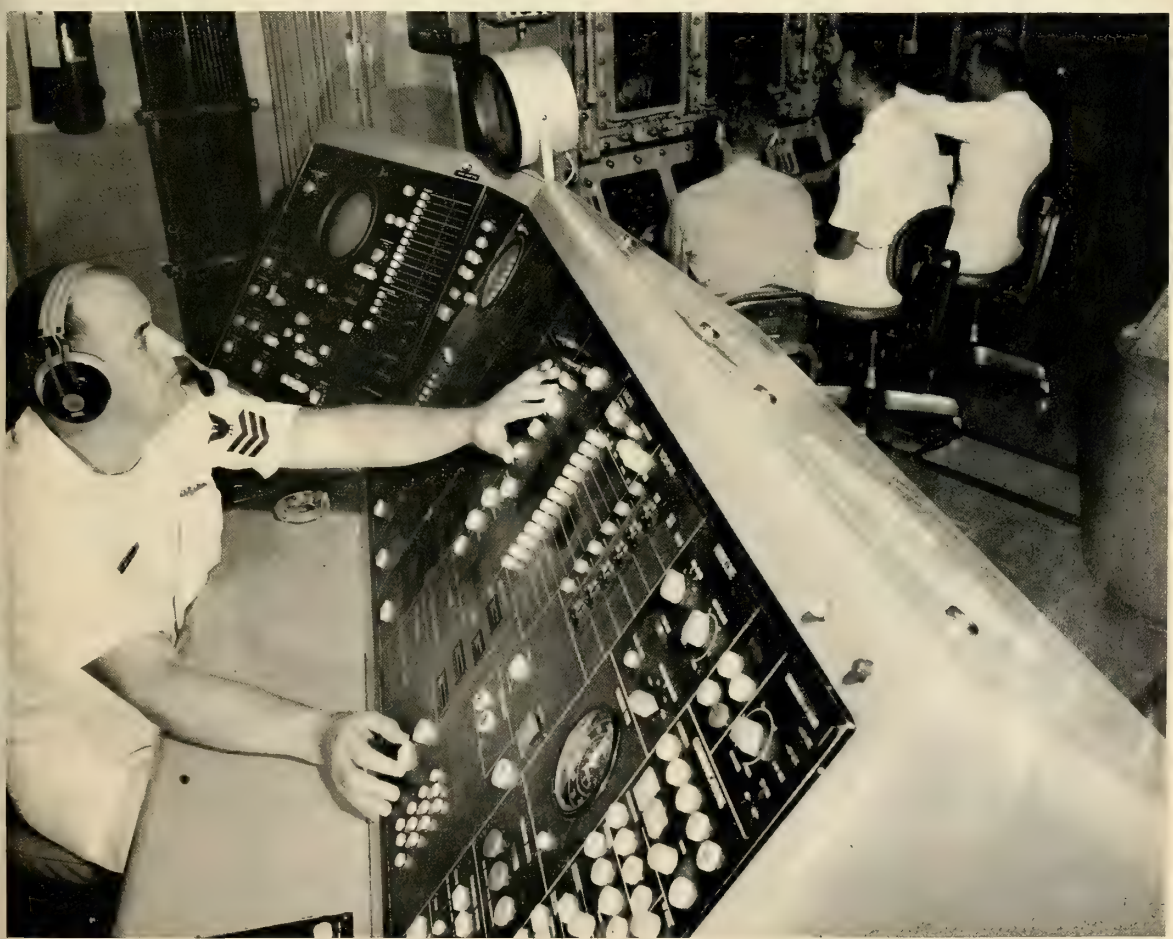
Developed, built and installed by Honeywell, Inc.'s California Ordnance Center in West Covina, the vast electronically controlled simulator occupies more than 7,000 sq. ft. of floor space on three floors and is comprised of three separate attack centers, a complex computer center employing a Honeywell H800, a tactical display room, and two command centers.

Each attack center duplicates one of those in operational use by the three classes of nuclear submarines. All of the exterior knobs, dials and controls and many of the rack-type subsystems are duplicates of operational hardware.

The initial contract for development of the center's electronic systems was awarded Honeywell in December, 1959, by the Naval Training Device Center, Port Washington, N.Y., and totalled $3.6 million. Reportedly, contract add-ons, modifications, etc., have stretched the total to more than $10 million.

The first of three attack centers was delivered in October, 1962, and was declared operational a year later.

PROGRAM operator's console in attack center is part of instructor's station that calls the shots in mock sea battles.



The remaining two centers were delivered during 1964. The complete trainer was declared operational early this year.

● **Trainer need**—The complexities of modern navigation systems, missile fire control and launching systems, communications, and sonar and radar detection and ranging systems demand skillful operators and officers to obtain optimum performance. The attack center's equipment permits operational experience in all the myriad tasks, with the external world simulated by the H800 digital computer system.

To train crews aboard operating nuclear submarines would be an inefficient, highly complex and costly project, the Navy says.

The trainer effectively solves this problem and also provides a secondary role—that of training senior command and staff officers in the direction and coordination of submarine task force groups with supporting aircraft and surface ships.

● **Attack centers**—The three attack centers employ both operational and simulated equipment to achieve realistic mockups and operation of the actual attack centers of the several classes of nuclear submarines. The layout of each attack center is similar to and based on the layout of the type submarine represented.

An attack center includes a fire-control system, navigation and plotting equipment, target-detection equipment (sonar, radar and periscope) and communications systems. All are necessary for complete training and are either actual operational equipment or are realistically simulated. The instructor's station in each attack center contains a program operator's console (POC), assistant program operator's console (APOC) for sonar input, and a projection plotting system.

Problem parameters, including type and number of targets and mode of operation (independent or coordinated), are established at the master instructor's console (MAS) for each attack center. Training problems are controlled locally from the POC. The POC operator sets up the problem in his attack center by selecting ocean scale on the projected plot, positioning the attack center's potential submarine targets and assigning weapons.

Operating independently, an attack center may use up to 21 problem vehicles including "own-ship," various weapons, and 12 targets. In a coordinated problem involving two or three attack centers, 33 problem vehicles are available. (These vehicles also may be used by the tactical display room, along with eight others which are exclusively reserved for the TDR.

After a problem begins in the attack center, the POC operator controls the action of targets, acts as own-ship helmsman, and monitors trainee actions by observing the projection screen and data displays. He may freeze the problem at any point for critique.

The assistant program operator provides the communication and data transmission functions of the sonar operator. Sonar signals from the APOC are transmitted to the conning, fire-control and plotting stations to activate visual presentations.

Projection systems used in attack centers are identical, each consisting of a bank of four tracking projectors and a screen. Own-ship, target and weapon tracks are displayed in different colors by three separate projectors. The program operator uses the fourth projector for manually inserting notations or other data for display.

As the problem develops, a servo-driven stylus scribes vehicle tracks on the surface of opaque-coated glass slides for projection onto the screen. The screen represents an ocean surface area that may be 8 x 16, 30 x 60, 125 x 250, or 250 x 500 nautical miles, as desired. The slides form a permanent record of the tactical problem and may be reviewed for post-problem critique.

Attack centers #1, #2 and #3 are equipped with operational fire-control systems Mk 112, Mk 101 and Mk 113 Mod 2, respectively. These are connected with the trainer's sensory devices; the H800 computer directly or indirectly furnishes inputs necessary for tactical problem solutions. Since operational fire-control systems are employed, they provide maintenance training for technicians.

BATTLE CONDITIONS prevail in another attack center. Trainees operate fire-control systems, left, and periscope, right. Fire-control systems are among operational equipment in attack center, a precise duplicate of its counterpart on a real sub.

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Each attack center has the ability to simulate launching of all tactical weapons carried by the submarine class represented. The run or flight of the weapon is calculated by the computer in real time and an assessment of hit or miss is made. All possible characteristics and capabilities of each weapon are programmed into the computer for this purpose.

● **Computer and interface equipment**—Normal functions performed by the H800 general-purpose digital computer system include problem generation, position and motion data generation for 41 (when used by the tactical display room) problem vehicles, simulation of various weapons characteristics, computation of relative target range and bearing with respect to each attack center, and trainer operation tasks, such as track projector time-sharing or display selection.

The various interface equipment necessary to link the computer with the attack centers and display room also was designed and built by Honeywell for this installation. These include a multiplexer for input of information received from various systems or consoles, a distributor to route computed output data back to the proper units and converters to present data signals in a form acceptable to simulating equipment.

● **Tactical display room**—The TDR seats 48 persons and is equipped with a vehicle-tracking projection system, projection screen and numerical status display boards.

In addition to providing for in-progress monitoring and post-problem critique of attack center problems, the TDR is used for controlling and observing war game maneuvers. These exercises can be run in real time or compressed time.

The projection system in the TDR is similar to those in the attack centers, except that eight projectors are used to provide an extra ocean area of 500 x 1,000 n. mi. Tactical problems in any attack center can be projected on the TDR screen. During a coordinated problem, all three attack centers are in the same exercise and their actions projected simultaneously on the screen. Information concerning problem and weapon status in the attack centers is presented on the numerical display boards.

Two command centers are provided for use by command or staff officers to engage in advanced tactical maneuvers. Command centers are furnished with status boards and communications facilities.

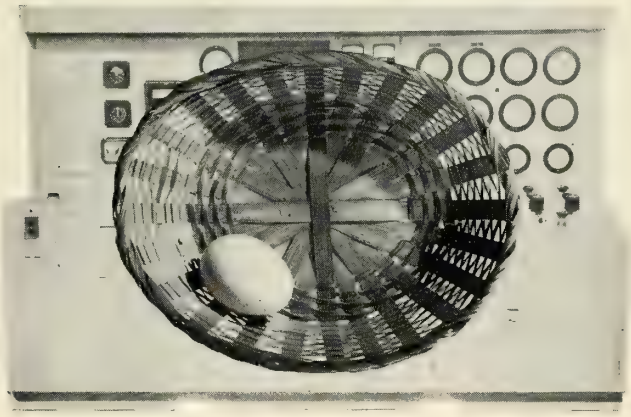
Problem control and monitoring for the entire trainer facility is accomplished through the master instructor's console, located in the tactical display room. The console operator initiates overall problem setup for the three attack centers by assigning specific types and numbers of targets to particular centers, establishing whether the centers will operate independently or in coordination with each other, and establishing other general problem parameters.

At any time, the MAS operator may monitor the progress of a problem in any attack center by observing displays at his console or by optically projecting the problem onto the TDR screen.

The design of the trainer, according to Honeywell, as well as the building space, provides for expansion of the system to include an additional attack center and the installation of new equipment.

As updated or new equipment or weapons become available, they may be added to the trainer with minimum disruption and expense. Many of the later modifications that change ship or weapon characteristics can be included in the trainer through computer program changes only. ■

ONE EGG—ONE BASKET



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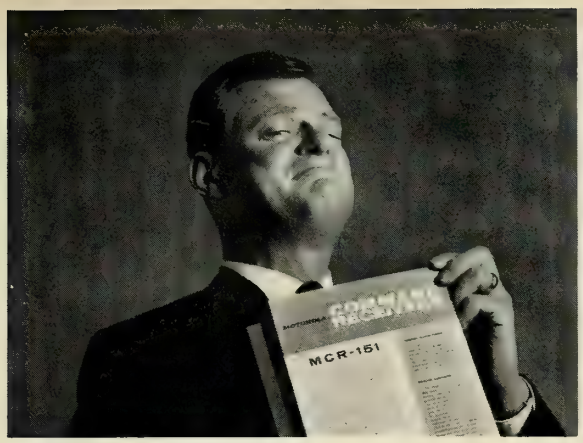

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So if you're working on a system that really calls for this unique receiver, mark the right places in the coupon below. Needless to say, there *are* other off-the-shelf Motorola units—the same ones which have already been successfully used on more advanced programs than any others. And they can satisfy a variety of requirements. Chances are that *one* of them will fulfill your particular application specs just fine. For example, here are brief descriptions of three of them:

MCR-503 — Used on Saturn digital command system; meets full NASA specs for quality and workmanship. A solid-state, crystal-controlled, double conversion superheterodyne FM receiver with a very low noise figure, MCR-503 is designed for use with an external decoder unit. It can be packaged to include any of the 20 standard IRIG tone decoder channels.

MCR-404 — Used on Minuteman, it features solid-state logic and switching, internal voltage regulation, special telemetry circuitry, and a noise-operated squelch channel.

MCR-312 — Used on Polaris and others, it employs 3 standard decoder channels (any of the 20 IRIG channels) and an isolated dc ground system with special transistorized telemetry circuitry, internal voltage regulation, and relay-operated logic outputs.

If none of these meets your requirements, we have others . . . all ready for immediate shipment. Additionally, we can quickly modify or adapt most standard models to fit special needs. So, use the coupon below to obtain the full story.

FOR DATA ON MCR-151

☐ *Yes, I have a "need to know" about the new MCR-151. Here's why: (use separate sheet if necessary)*_____

FOR DATA ON OTHER MOTOROLA COMMAND RECEIVERS

Please send data on these Motorola command receivers:

☐ *MCR-503* ☐ *MCR-404* ☐ *MCR-312* ☐ *Other, please specify needs below.*

*My command receiver applications are*_____

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Experience in one or more of these areas: **1.** System engineering involving missile or fire control systems. **2.** Field engineering on airborne systems. **3.** Test evaluation. **4.** Pulse doppler and other radar systems. **5.** Digital computer —airborne system. **6.** Inertial and microwave components. **7.** Circuit design, electrical power, armament control and IR subsystems, navigation and target tracking systems. **8.** Aircraft display and controls, human factors and electronic packaging.

Education: B.S. in E.E., M.E. or Physics. Applicants should be articulate in writing and communication as related to their responsibilities. U. S. citizenship required.

MISSILE SYSTEM FUNCTIONAL DESIGN

Responsibilities: Determine functional design requirements for advanced air-launched missiles; the design of such systems to meet customer requirements and theoretical analysis of system performance; coordinate and assist engineering departments in the development of equipment to fulfill the system requirements.

Experience: Two years minimum in one or more of the following fields: **1.** System engineering on missile or fire control systems. **2.** Field engineering on airborne fire control systems or missile systems. **3.** Test and evaluation of comparable systems. **4.** Radar systems (pulse doppler). **5.** Target tracking systems. **6.** Autopilot and control systems. **7.** Microwave systems. **8.** Digital computers. **9.** Navigation systems. **10.** Inertial components. **11.** Electrical power and armament control subsystems. **12.** Circuit design and electronic packaging.

Education: B.S. in E.E., M.E. or Physics. Articulate in communications. U.S. citizenship required.

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FCC Considering Comsat Rates

Proposed rates for communications using the *Early Bird* satellite are now being considered by the Federal Communications Commission. The tariff, filed May 28 by Communications Satellite Corp., will go into effect June 27 unless the FCC finds it is not "in the public interest." The tariff covers transmission and reception of voice, television, record, data, telephoto and facsimile signals between the satellite and Comsat's ground station at Andover, Me. It applies only to U.S. common carriers and only to communications between Andover and the *Early Bird* satellite. If the FCC authorizes entities other than the common carriers to buy service directly from Comsat, the rates will be supplemented. All users of *Early Bird* must make their own arrangements for transmission and reception between the satellite and the European stations. Monthly rates for a two-way voice channel between Andover and *Early Bird* have been set at $4,200 on a 16-hour-day, 7-day-week basis. It is not expected that use of *Early Bird* will affect the telephone rates charged to users.

Mergers and Acquisitions

Raytheon Co., Lexington, Mass., plans to acquire the assets and business of Dage-Bell Corp., Michigan City, Ind., manufacturer of television equipment, language laboratories and learning center systems. The acquisition—expected to be completed by June 30—is the sixth for Raytheon in the last year (M/R, May 10, p. 35). Dage-Bell will function as a subsidiary within Raytheon's Equipment Div. . . . *International Electronic Research Corp., Burbank, Calif., has purchased the assets of the H. A. Henderson Co., Los Angeles. Henderson produces lubricant and coating products. It will be operated as the Henco Coatings Facility of IERC.* . . . Teledyne, Inc., Hawthorne, Calif., has acquired Glenn Pacific Corp., manufacturer of industrial controls and factory automation equipment. Teledyne will trade one share of common stock for 10 shares of Glenn Pacific. Glenn Pacific has plants in Oakland and Newark, Calif. . . . *Analex Corp., Boston, has acquired Data Communications, Inc., producer of electronic systems and components. The Moorestown, N.J., firm will be operated as a subsidiary of Analex. Operations will continue with DCI's present staff.*

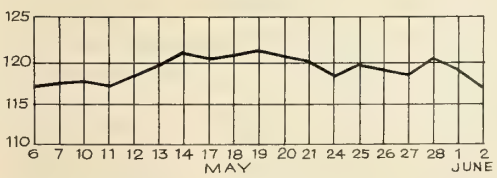
New Activities

Electro-Optical Systems, Inc., Pasadena, Calif., has established a research department for broad spectrum studies of biomedical phenomena. Emphasis will be on space bioscience experiments, support of man in extended space flight and human survival in deep-sea submergence. Facilities include both EOS laboratories and private hospital surgeries in the Pasadena and Los Angeles areas. Lawrence H. Taylor, M.D., will manage the new department. . . . *North American Aviation, Inc., has set up a Deep Submergence Systems Program Office at its El Segundo, Calif., facility. Dr. D. H. Pickrell, Jr., has been named manager.* . . . TRW Space Technology Laboratories, Redondo Beach, Calif., has consolidated its manufacturing operations and related functions under a single management. Frederick W. Hesse, vice president for operations, will head the new group. . . . *Delta Sonics, Inc., Hawthorne, Calif., has formed a subsidiary company, Inspection Systems, Inc. The new company will develop and manufacture ultrasonic flaw detection equipment.*

International

International Telephone & Telegraph Corp. will act as prime contractor and project manager for a group of firms involved in NATO's Air Defense Environment (NADGE) program (M/R, Oct. 12, p. 14). The ITT Nadge Consortium is one of several groups formed at NATO's request to bid on the $300-million program. The group includes Associated Electrical Industries, Compagnie Generale de Telegraphie Sans Fil, Elliott Automation, Litton Industries, Univac Div. of Sperry-Rand Corp., J. L. Kier and ITT. Headquarters of the consortium are in Paris. . . . *Oak Electro/Netics Corp., Crystal Lake, Ill., has established a European Research and Development Center. The center will be located at the firm's recently acquired branch company, N. V. Messa Electronics, in Emmen, Holland. Initial research emphasis will be on radio and television tuners.* . . . Telemetrics, Inc., Santa Ana, Calif., has opened an office in Munich, West Germany. The division will handle the firm's products as well as field engineering, field support and customer services. Telemetrics is a subsidiary of Technical Measurement Corp.

Missile/Space Stock Index



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AIR FORCE

$3,264,413—**Belock Instrument Corp.,** Lawrence, Mass., for manufacture of radar equipment.

$3,000,000—**TRW, Inc.,** Redondo Beach, Calif., for continued work on unspecified space programs.

$2,344,100—**The Boeing Co.,** Rapid City, S. D., for modernization work on early-model *Minuteman* missiles.

$1,910,000—**Martin Marietta Corp.,** Denver, for supplies and services in support of *Titan II* long-term readiness program.

$1,500,000—**Goodyear Aerospace Corp.,** Litchfield Park, Ariz., to build special highway units for transportation of the *Minuteman II* missile.

$1,042,037—**North American Aviation, Inc.,** Los Angeles, for continued work on *Thor* rocket propulsion systems.

$245,706—**Aerojet-General Corp.,** Liquid Rocket Plant, Sacramento, Calif., for metallized propellant and combustion chamber development.

$245,706—**Aerojet-General Corp.,** Liquid Rocket Plant, Sacramento, Calif., for hydrostatic combustion seal demonstration feasibility.

$203,170—**Martin Marietta Corp.,** Denver, for study of system-coupled instability analysis techniques.

$143,000—**General Dynamics Corp.,** Convair Div., San Diego, Calif., for engineering effort to complete optimization of a lightweight insulative composite for incorporation into an advanced aerospace vehicle.

$98,500—**Watkins-Johnson Co.,** Palo Alto, Calif., for fabrication of wide-band traveling-wave tube amplifiers.

$40,000—**Aerojet-General Corp.,** Sacramento, Calif., for overhaul and hot fire test of *Titan II* propulsion system and overhaul of components.

$34,992—**University of Michigan,** Ann Arbor, for six months' research study to investigate missile-ionosphere coupling phenomena.

ARMY

$3,685,661—**General Dynamics Corp.,** Pomona Div., Pomona, Calif., for a modification to the *Mauler* feasibility validation program control.

$106,800—**A. G. Proctor Co., Inc.,** Aurora, Colo., for *Redhead/Roadrunner* facility at Fort Bliss, Tex.

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GLOBE

General Telephone and Electronics Corp, Sylvania Electric Products Inc., New York City, for the development and production of extremely ruggedized electronic equipment for use in the high-acceleration *Sprint* missile (amount not disclosed).

NAVY

$1,633,974—**Sanders Associates, Inc.,** Nashua, N.H., for antennas for *Shrike* missile.

$1,200,000—**Sperry Rand Corp.,** St. Paul, Minn., for data-processing equipment.

$737,577—**Thiokol Chemical Corp.,** Reaction Motors Div., Denville, N.J., for research and development of high-performance missile propulsion system.

$448,234—**General Electric Co.,** Defense Electronics Div., Pittsfield, Mass., for engineering services in support of *Tartar* and *Talos* missiles.

$447,000—**L. B. Samford, Inc.,** South Miami, Fla., for construction of space surveillance station at Hawkinsville, Ala.

$197,921—**Operations Research Inc.,** Silver Spring, Md., for operational analysis and research studies related to underwater weapons systems.

$119,278—**Interstate Engineering Corp.,** Interstate Electronics Corp., Anaheim, Calif., for a synchro data-collection system.

$104,000—**Sanders Associates, Inc.,** Nashua, N.H., for *Shrike* missile control sections.

$99,830—**Goodyear Aerospace Corp.,** Akron, Ohio, contract modification for value engineering program to comprise a thorough functional evaluation of *Subroc*.

$76,051—**Booz-Allen Applied Research, Inc.,** Bethesda, Md., for ASW sensor studies.

$73,614—**The Boeing Co.,** Aero-Space Div., Seattle, for research and development on semi-continuous pressure sintering of ceramics.

$70,265—**Hercules Powder Co.,** Wilmington, Del., for filament-wound rocket motors.

$48,881—**United Technology Center,** Sunnyvale, Calif., for feasibility study of predicting blast effects from rapid deflagration of composite solid propellants.

NASA

$1,767,201—**Electronic Communications, Inc.,** St. Petersburg, Fla., for current engineering and production programs for flight-control computers for *Saturn IB* and *Saturn V* space vehicles.

$1,347,547—**Thiokol Chemical Corp.,** Huntsville, Ala., for Castor motors and accessories.

$804,530—**G. T. Schjeldahl Co.,** Northfield, Minn., for passive geodetic satellite inflatable sphere assemblies.

$666,627—**Space-General Corp.,** El Monte, Calif., for *Aerobee* 150/150A attitude-control system.

$484,525—**General Electric Co.,** Missile and Space Div., Valley Forge, Pa., for *Nimbus* technical control center.

$319,694—**Martin Marietta Corp.,** Baltimore, for study of micrometeoroid deep-space satellite.

$231,542—**Sperry Rand Corp.,** Sperry Gyroscope Co., Great Neck, N.Y., for yaw rate and position sensor.

$150,000—**California Computer Products, Inc.,** Anaheim, Calif., for system design and logic design study of a redundant command and clock subsystem for the *Nimbus B* spacecraft.

Kinelogic Corp., Pasadena, Calif., for study and prototype development of a data record/reproduce system for use by astronauts during Moon exploration (amount not disclosed).

Hughes Tool Co., Oil Tool Div., Houston, to design a sampling device for obtaining geologic samples of the lunar and planetary surfaces for analysis (amount not disclosed).

INDUSTRY

$3,500,000—**General Electric Co.,** New York City, from **Hughes Aircraft Co.,** Culver City, Calif., for a large-scale computer to replace five computers used in solving problems in developing missile and aerospace equipment.

$2,000,000—**Redcor Corp.,** Canoga Park, Calif., from **Radio Corp. of America,** New York City, for computer components.

$200,000—**Fairchild Camera and Instrument Corp.,** Du Mont Laboratories, Clifton, N.J., from **Belock Instrument Corp.,** College Point, N.Y., for storage tubes.

$150,000—**Applied Technology Inc.,** Palo Alto, Calif., from **Lockheed Missiles and Space Co.,** Sunnyvale, Calif., for delivery of several panoramic and manually tuned receiver systems.

DEFENSE ELECTRONIC SUPPLY AGENCY

$300,843—**General Telephone and Electronics Corp.,** Sylvania Electric Products Inc., Seneca Falls, N.Y., for the production of electron tubes for the military.

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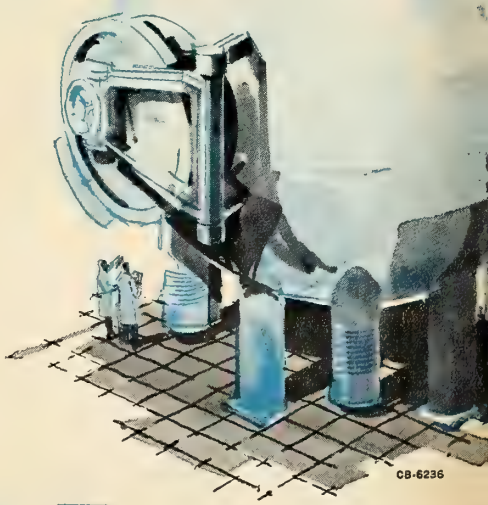

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names in the news

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Dr. Arthur Goldsmith: Joined System Sciences Corp. (formerly ITT Intelcom) as deputy director of the Communication Applications Div., where he will direct and coordinate the analyzing and planning for conventional and satellite communications systems.

K. Robert Hahn: Promoted to corporate vice president in charge of long-range planning with additional corporate responsibilities relating to operations of several divisions of Lear Siegler, Inc. Named to succeed him as president of LSI's Power Equipment Div. was **Andrew F. Haiduck.**

Col. Jerry C. Glover (USAF Ret.): Joined the National Weather Satellite Center as head of satellite operations. He was formerly deputy commander of the Air Force's Fourth Weather Group.

Bob Jarmalow: Elected president of CBC Industries, Inc., manufacturer of fused and circuit-breaker model electrical outlet boxes.

Francis P. Devine: Appointed manager, NASA Programs-Operations for Electronic Communications, Inc. He was formerly manager of NASA programs for General Dynamics/Electronics.

Herbert S. Bright: Appointed director/systems programming at Informatics Inc. in Washington, D.C. He was formerly with Philco's Computer Div.

J. David Hopkins, Jr.: Appointed to the newly-created position of vice president of commercial activities for Itek Corp.

Maurice E. Esch: Appointed director of Honeywell Inc.'s military and space sciences department in Washington, D.C.

Harry E. Seston: Named president of Oak-Hart Manufacturing (Canada) Ltd., a subsidiary of Oak Electro/Netics Corp.

George H. Cook: Elected a vice president of Reeves Industries, Inc. He is executive vice president and general manager of Alloy Surfaces Co., Inc., a subsidiary of Reeves.

Lloyd G. Hallamore: Promoted to president of the Astronics Div. of Lear Siegler, Inc. A corporate vice president of the company, he will continue to serve as president of LSI's Electronic Instrumentation Div.

J. P. Rogan: Named vice president and director of operations of Douglas Missile and Space Systems Div. A veteran of 28 years with Douglas, he had been vice president and operations director at the division's Space Systems Center.

Albert G. Handschumacher: Elected to the board of directors of Spacerays, Inc., designers and manufacturers of electro-optical systems and devices for industrial, medical and military uses, with primary emphasis on laser technology.

Dr. Martin Nahemow: Appointed senior research physicist and manager of the Solid State Laboratory of Newtek, Inc. He will have responsibility for the development of solid-state image sensor systems.

Joseph F. Alibrandi: Elected a vice president of Raytheon Co. He is also assistant general manager of the firm's Missile Systems Div.

Dr. Robert C. Seamans, Jr.: Has been named the 1965 recipient of the Godfrey L. Cabot Award of the Aero Club of New England. He was selected for his outstanding contributions to aeronautics. He is associate administrator of the National Aeronautics and Space Administration.

James L. Pyle: Promoted to assistant to the president of California Computer Products, Inc. He was formerly director of marketing.

Bruno W. Augenstein: Named research adviser to the president of the Institute for Defense Analyses. Also named to new positions were **Dr. Milton U. Clauser,** director of IDA's Research and Engineering Support Div.; and **Dr. Robert H. Fox,** deputy director of the same division.

C. Frederick Graham: Elected president of Crouse-Hinds Co. of Canada, Ltd.

George Litchford: Resigned his position as head of Aviation Systems Research at Airborne Instruments Laboratory to start a consulting business.

George J. Fehrenbach: Retired from Speer Carbon Co. after more than 40 years service. He is chairman of the company, a division of Air Reduction Co., Inc. He will continue as a consultant.

John F. Burlingame: Appointed general manager of General Electric Co.'s Radio Guidance Operation.

Edwin K. Chapman: Appointed manager of Applied Technology, Inc.'s Washington and Southeast Area Office.

Jerry S. Frank: Appointed executive secretary of the Strategic Industries Assn. He is founder and president of IMA, Inc., a management consultant firm that serves a variety of clients in the aerospace, electronics and other defense-oriented industries.

Dr. Richard I. Tanaka: Named consultant to the president of California Computer Products, Inc.

Frank H. Worm: Appointed vice president in charge of engineering for Flex-Weld, Inc.

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JUNE

International Symposium on Global Communications (GLOBECOM VII), sponsored by the University of Colorado and National Bureau of Standards, Boulder, Colo., June 7-9.

Applied Mechanics-Fluids Engineering Conference, sponsored by American Society of Mechanical Engineers, Catholic University of America, Washington, D.C., June 7-9.

Short Course in Cryogenics at the University of Alabama, Huntsville, Ala., June 7-11.

Techniques and Management of Defense Value Engineering, sponsored by the National Defense Education Institute (NDEI), Philadelphia, June 7-11.

51st Norelco X-ray Analytical School, sponsored by Philips Electronic Instruments, Ambassador Hotel, Chicago, June 7-11.

Metals and Production Engineering Conference, sponsored by American Society of Mechanical Engineers, Hotel Claremont, Berkeley, Calif., June 9-11.

Fourth Materials Symposium of the Air Force Materials Laboratory, Deauville Hotel, Miami Beach, Fla., June 9-11.

Economic Aspects of Research Management, sponsored by American Society for Metals and the Metallurgical Society of American Institute of Mining, Metallurgical and Petroleum Engineers, Northwestern University, Evanston, Ill., June 9-11.

26th Paris International Air Show, Le-Bourget, Paris, June 10-21.

Ocean Science and Ocean Engineering Conference and Exhibit, sponsored by The Marine Technology Society and The American Society of Limnology and Oceanography, Washington Hilton Hotel, Washington, D.C., June 14-17.

Propulsion Joint Specialist Conference, sponsored by the American Institute of Aeronautics and Astronautics, Air Force Academy, Colorado Springs, Colo., June 14-18.

International Symposium on Multivariate Analysis, sponsored by Aerospace Research Laboratories (Air Force), Dayton, Ohio, June 14-19.

Tenth Anniversary Scientific Seminar, sponsored by the Air Force Office of Scientific Research in cooperation with the University of New Mexico and the Air Force Missile Development Center, Cloudcroft, N.M., June 14-25.

1965 Heat Transfer and Fluid Mechanics Institute, sponsored by the American Institute of Aeronautics and Astronautics, Los Angeles, June 21-23.

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Judge and Jury

IT IS ALWAYS a grim pleasure to see the tables turned on an inquisitor. That now has happened to the General Accounting Office. The investigator is being investigated. Responsible for this is the Military Operations subcommittee of the House Committee on Government Operations.

Popularity of GAO in this industry long has been on the same level as a persistent toothache, not because of GAO's quite legitimate auditing activities, but because the agency, clutching its gift of 20-20 hindsight, has gone far beyond its intended scope.

GAO has used its tremendous powers carelessly with little respect for industry reputation and performance. Just how universally this opinion is held in the industry was evident in the subcommittee hearings.

Even Aerospace Industries Assn. was moved to take a public stand on the issue, in itself a signal development. AIA President Karl G. Harr, Jr., testified: "We feel that the GAO, whether or not in accordance with what Congress desires it to do, has become unduly involved in the exercise of managerial opinion, both as to management judgments by the procuring agencies and management judgments by industry; that such opinion moreover carries inordinate weight because of the general assumption that what the GAO states is accounting or auditing fact; and that the result of these two factors is to inhibit the optimum working of the procurement system in the national interest."

Mr. Harr pointed out that it is most offensive to companies in the industry to find themselves tried by headlines, which, because of GAO's position, tend to be accepted as fact when they most often are only opinions.

President Daniel J. Haughton of Lockheed Aircraft Corp. stated: "I feel quite strongly that the GAO is getting more and more into the area of business judgments—not just those relating directly to contract performance, but those in the area of general operation of private business."

Mr. H. M. Horner, chairman of the board of United Aircraft Corp., declared: "We believe, on the basis of our experience over a number of years, that the GAO has overstepped the boundaries of its proper function and has engaged in certain practices and procedures which are beyond the scope or abilities of its personnel and which are detrimental to the efficient execution of Government procurement operations."

Mr. Horner told the subcommittee that GAO pays little or no attention to the quality of the product delivered under the contracts it reviews nor to the effect on quality or delivery schedules which might result from yielding to its recommendations.

Mr. Howard W. Neffner, vice president-government contracts for The Boeing Co., said: "There is grave and growing concern on the part of many, both within industry and Government, as to whether the present and expanding scope and impact of GAO's activities and methods are in keeping with the intent of Congress and consistent with the public interest. The Boeing Co. shares this concern."

Mr. Neffner pointed out bluntly that Boeing disagrees with most of GAO's opinions and recommendations, with many of its concepts and methods, and challenges its competency to direct procurement policies and practices.

Dept. of Defense spokesmen voiced similar Pentagon dissatisfaction with GAO activities.

NO ONE EXPECTS an agency charged with the duties of GAO to make itself popular while carrying them out. But the unanimity of the chorus raised against the agency leaves little doubt that it consistently has overstepped its bounds. Its judgment when it does so also leaves much to be desired.

To understand this, one only has to look as far as one of the recommendations in its recent report on Aerospace Corp. Extending itself far beyond its auditing function, GAO declared that Aerospace Corp. has no need of a public relations department. Not only is this no business of GAO, it is a ridiculous statement on the face of it. No one with the slightest knowledge of the function of a PR department could make such a recommendation. Despite its non-profit nature, Aerospace is like any other company (and indeed most Government agencies) in that it must be prepared to handle a continual demand from the press for news of its activities. Established to attract high-level scientific and engineering talent, the firm also must maintain a public image which matches this goal. Its public relations department plays a major role in this.

For GAO to recommend elimination of the department as an economy measure amply demonstrates how little it knows about management and how greatly it values its dollar judgments above common sense.

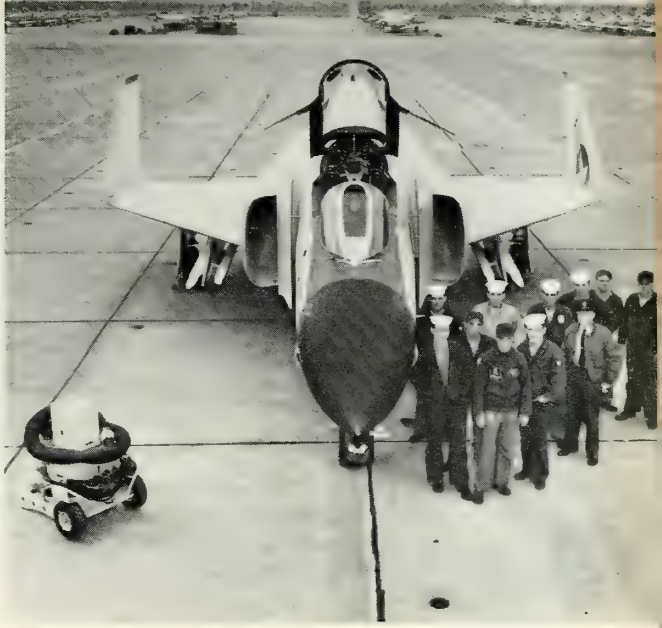
All of the industry spokesmen appearing before the subcommittee agreed that GAO has a necessary and useful, if unpleasant, role to fill. Mr. Neffner of Boeing perhaps did the most to make this clear when he pointed out that there are two types of GAO reports: one, primarily factual; the other, difference of opinion on matters of judgment—opinion aided by perfect hindsight.

The first involves GAO audit in cases where incomplete, inaccurate, or non-current cost or pricing data was supplied or relied upon in contract negotiations. Mr. Neffner noted that it is long-standing corporate policy at Boeing, as it is at most other companies, to adjust contracts under such circumstances, no matter how they come to light.

"The bulk of the cases, numerically and in dollar value, fall in the second category," Mr. Neffner said. "Here, voluntary refunds demanded by GAO from us are based upon GAO disagreement with the judgment of the negotiators in evaluating and using the available cost or pricing data. Such cases do not involve any charge that the data was imcomplete, inaccurate, or out of date. They boil down to mere differences of opinion; hindsight versus foresight."

The Boeing executive has cut to the heart of the issue. We hope the investigation leads to much-overdue legislation curbing these abuses.

William J. Coughlin



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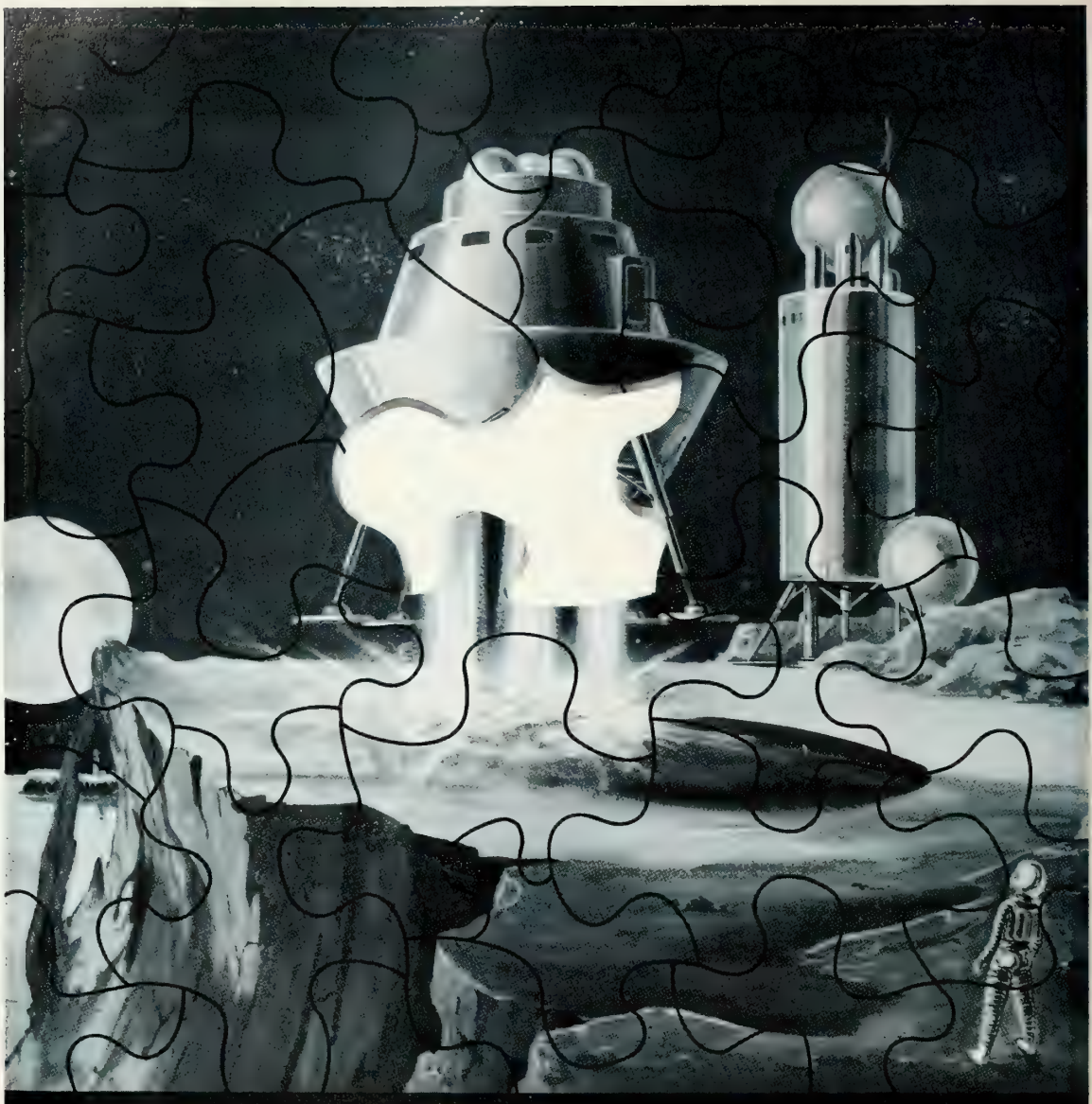

Which counts more: the sum or the parts?

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JUNE 14, 1965

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

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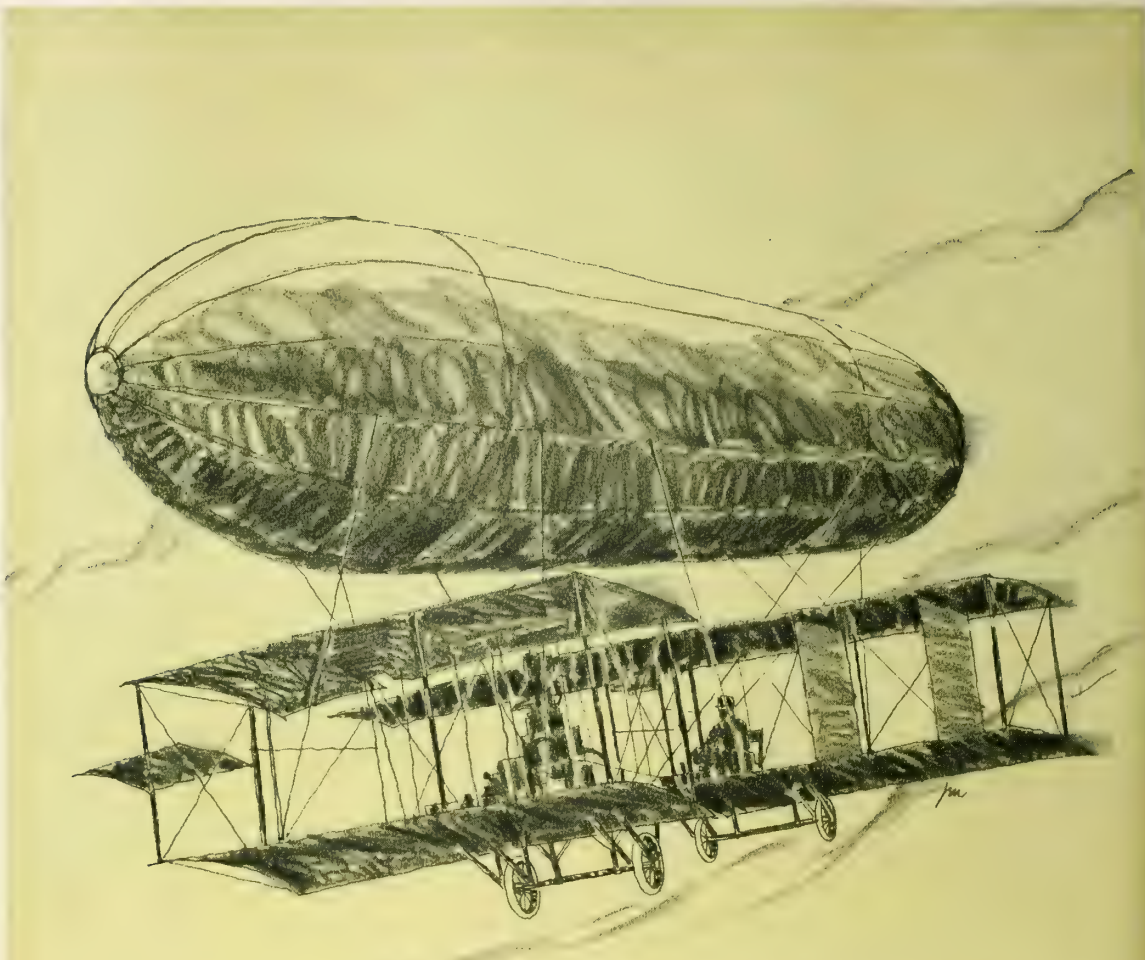
Gemini 4 Spurs Role of Military in Space

Upgrading Set for ICBM's

British Polaris on Schedule

AF Materials Meet Detailed

White Begins His Historic Space Walk



M. César had to compromise to solve his weight problem; pity he didn't have Beryllium

Considering materials available in the 1900's, early aircraft designers showed remarkable ingenuity. In 1911, a Frenchman named César built a combination dirigible-biplane that actually flew—but not very far.

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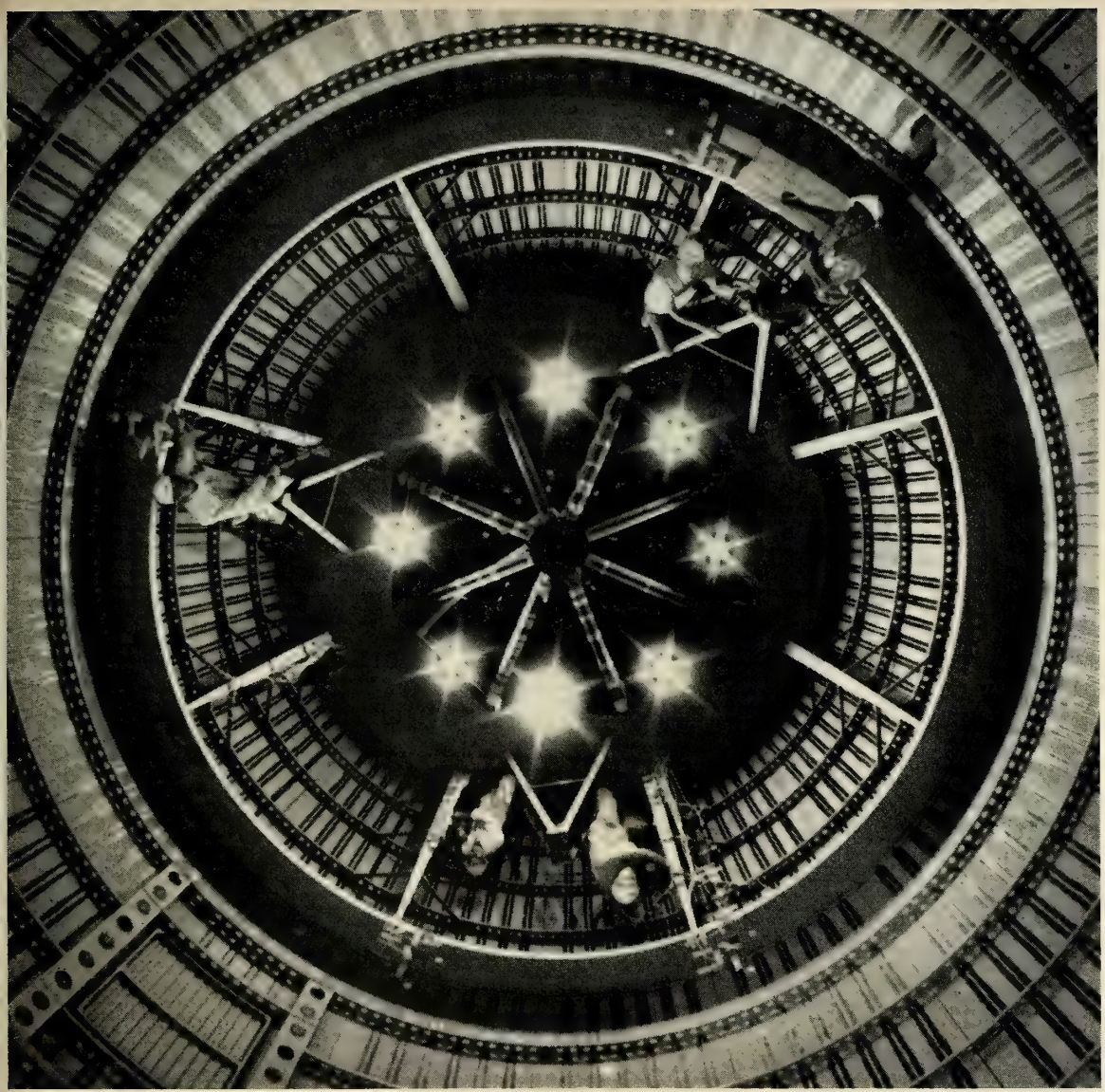

Careers on the move in **manned space programs**

Shown here is a section of the Douglas S-IVB stage of *Saturn* being readied to undergo strains beyond any it will meet when it powers the *Apollo* astronauts from earth orbit to moon orbit.

These tests take place in one of the eleven superbly equipped buildings at the Douglas Space Systems Center. Here, in the most modern facilities in the aerospace industry, engineers and scientists are working on great programs of this decade and the next.

Douglas missile and space projects include the design and development of orbiting space laboratories, moon and planetary exploration vehicles, space boosters and great new missile systems.

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missiles and rockets

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Volume 16, Number 24 June 14, 1965

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THE COVER

Astronaut Edward White floats out from Gemini 4 spacecraft at the beginning of his 20-minute walk in space during the third revolution of the 97-hour, 57-minute, 49-second flight. Command Pilot James McDivitt filmed White's extravehicular activity. See story, page 14.

JUNE 14 HEADLINES

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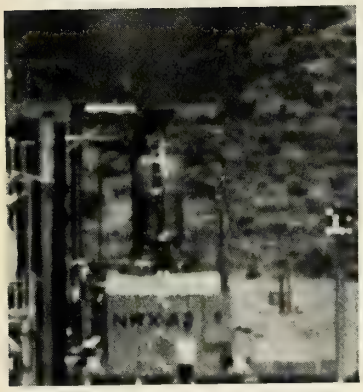
48,000 copies this issue

"HOT" TEST at JACKASS FLATS



Above is an unclassified telephoto of the NRX-A2 "hot" test conducted by the Astronuclear Laboratory of Westinghouse Electric Corporation at Jackass Flats, Nevada.

The test was made under a sub-contract in the NERVA Program directed by the Space Nuclear Propulsion Office, in conjunction with the AEC and NASA.

This successful power test was the first in the NRX series of reactors and it employed a GLC special graphite in a prime role.

GLC special graphites are playing an increasingly important part in nuclear power applications. May we have the opportunity of exploring with you the contributions GLC special graphites can make to your projects in this area?

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letters

World War II 'Missilery'

To the Editor:

With regard to your editorial, "Give Them The Tools," of your May 24th issue, you may be interested to know that during World War II the Royal Air Force developed some very effective tools to cope with the problem of bridge destruction from the air. These were the "tallboy" (12,000 lbs.) and "grand slam" (22,000 lbs.) bombs. They were streamlined, spin-stabilized, free-falling missiles which, when dropped from altitudes of 20,000 feet or higher to attain a supersonic impact velocity, penetrated the ground or river bed to a depth where the delayed explosion could undermine and topple the nearest bridge pier and its attached spans. Thus the problem of accuracy was simplified since the missiles need not contact the bridge structure to cause destruction, and they need only be dropped within a critical zone either side of the bridge.

In addition, these missiles penetrated and collapsed such "invulnerable" targets as rail tunnels (Saumur), underground rocket dumps (Siracourt, Creil, Watten, Wizernes), and the reinforced concrete roofs of U-boat pens (Brest, Ijmuiden, Bergen, Pootershaven, Hamburg, Bremen). At Bremen two "grand slams" exploded through a roof of 23 ft. of solid reinforced concrete.

Lawrence E. Truppi
Asheville, N.C.

'Brezhnev Blockbuster'

To the Editor:

In commenting on the Russian development of large solid-fueled rockets (M/R May 17, pp. 16 & 17), as evidenced by the pictures of the May 9 parade in Moscow, it may be that you have overlooked an even more remarkable Russian technological development. Note that the "Brezhnev Blockbuster" is supported by a carriage having only eight truck tires. The better grade of American truck tires (10.00 x 20, 14 ply, 90 lbs. pres.) have a load-carrying capacity of 5,120 lbs., or 8 x 5,210=41,680-lb. capacity for the entire carriage. The missile itself appears to contain at least 10 times the volume of one of our solid-fuel rockets, the *Polaris*, which weighs somewhat over 30,000 lbs.

Consequently, each of the Soviet tires, apparently, is at least capable of bearing a load of $\frac{30{,}000 \times 10}{8} = 37{,}500$ lbs., a truly incredible development which suggests that the missile ought to be re-nicknamed the "Brezhnev Baloneybuster."

David E. Matzke
Kensington, Md.

To the Editor:

The pictures accompanying your article indicate that the Russians might have made amazing advances in fields other than missile technology.

The "Brezhnev Blockbuster" said to be 120 ft. in length is supported by two axles and eight tires, indicating our major tire manufacturers and highway engineers could learn something from the Russians.

If the missile pictured on the front cover and page 16 is "for real," the weight must be tremendous. The pictures do not indicate the tires flattened or the roadway disintegrating under the apparent load; thus it would appear that both tire and street construction in Russia have reached an advanced state of know-how and practical application.

Jack E. Pettijohn
Rockville, Md.

As mentioned in the M/R text accompanying the photographs, there is doubt among U.S. experts as to whether the 120-ft. missile shown is, in fact, a solid-fueled weapon. The weight factor, among others, seems to indicate that the missile paraded may have been a liquid-fueled weapon minus propellant—or perhaps a mockup of a solid-fueled missile.—Ed.

To the Editor:

Your article refers to three pictures, one on page 16 and the two in the upper left of page 17, as being of the same rocket.

This may be true but if so the camera is so foreshortened that it is hard to believe. The long pointed nose and the distance between the two stages seem to be completely different. Even when you check out the size of the tires to determine the angle of the lens, it is hard to believe that these are the same rocket.

R. A. Hickman
Manager, U.S. Government Marketing Dept.
The Dow Chemical Company
Midland, Mich.

It appears to us that the apparent discrepancy is an optical illusion.—Ed.

Surveyor Retro-motor

To the Editor:

Reference your article entitled "Facility Refines Motor Testing" (M/R, May 10, p. 32), which stated that "checking of the thrust alignment for the *Surveyor* retro-motor is now under consideration but not yet scheduled at AEDC."

Tests to determine thrust vector misalignment for the *Surveyor* retro-motor were conducted during the period Aug. 18-Sept. 9, 1964, in Propulsion Engine Test Cell (J-5) here at AEDC. These tests were performed in a Rigid Horizontal Six-Component Thrust Stand (without spinning). The results obtained were judged good enough to merit a discussion of the techniques involved at the AIAA Unmanned Spacecraft Meeting in Los Angeles.

R. L. Davis
Project Engineer
J4/J5 Projects Branch
Rocket Test Facility
Arnold Engineering Development Center
Arnold Air Force Station, Tenn.

Another RD and E capability report from ALLIS-CHALMERS

Fuel cell A-OK after 1,400 hours... and still running!

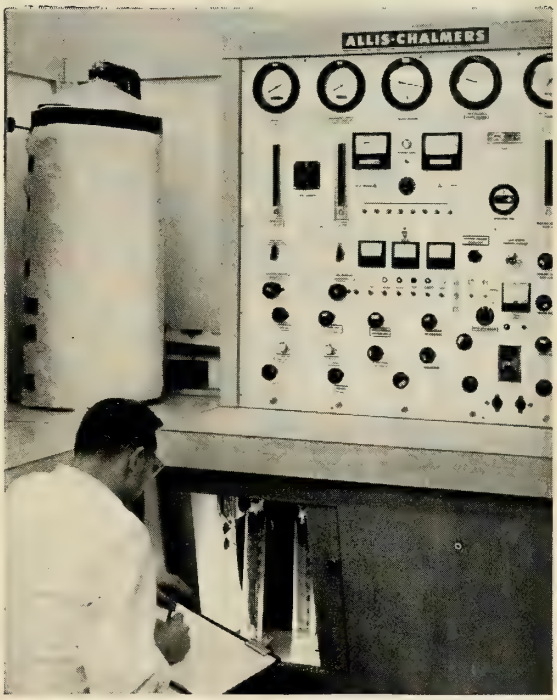
An Allis-Chalmers 28-volt fuel-cell system has successfully operated for more than 1,400 hours — producing both electrical power and drinking water from hydrogen and oxygen. And it is continuing to rack up running time during performance testing in Milwaukee. Allis-Chalmers built this advanced system for NASA.

What's so important about 1,400 hours? A spacecraft could make nine round trips from earth to moon in 1,400 hours. Allis-Chalmers scientists and engineers feel this system's performance proves such fuel cells are suitable power sources for prolonged space missions — such as space stations in orbit 30 to 45 days.

The Allis-Chalmers system converts chemical energy of hydrogen and oxygen directly into 28-volt electricity. During its initial 1,400-hour performance, it efficiently supplied power outputs ranging from 800 to 2,300 watts. Total energy delivered so far is 1,430 kilowatt-hours. Plenty of power for aerospace applications!

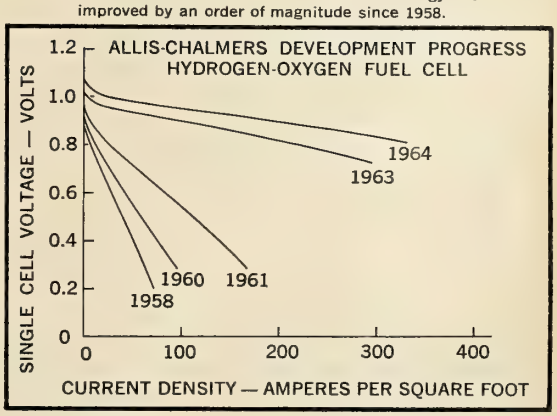
The system is producing 2½ to 3 gallons of water per day, enough for two astronauts. Purity of the water is assured because a distillation process is used to remove moisture from the Allis-Chalmers system. A built-in capillary membrane (we don't need pumps) takes out the water in vapor form. Simply condense it, collect it, and drink it as needed.

May we discuss your aerospace and defense fuel-cell application? Write: Space and Defense Sciences Department, ALLIS-CHALMERS, Box 512, Milwaukee, Wisconsin 53201.



A-C research scientist logs the production of drinking water during 1,400-hour testing of the 28-volt fuel-cell system.

Chart shows Allis-Chalmers fuel-cell technology has improved by an order of magnitude since 1958.



FUEL-CELL design for Aerospace and Hydrospace applications is but one of the opportunities open today for qualified scientists and engineers at Allis-Chalmers. For information concerning employment write to: Manager of Professional Placement, Allis-Chalmers, Milwaukee, Wisconsin 53201.

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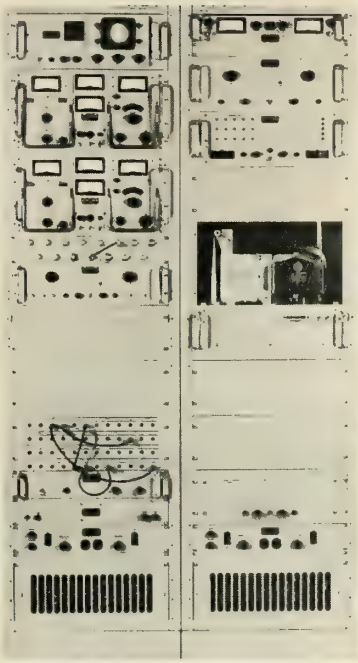

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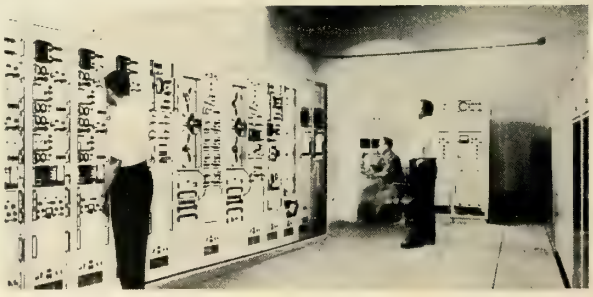

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The Countdown

WASHINGTON

Moon Landing in Three Years?

Dr. Joseph Shea, director of the *Apollo* spacecraft program at Manned Spacecraft Center, believes that if all goes well the U.S. could land on the Moon as early as mid-1968. Such a schedule would mean two straight successful unmanned flights of the *Saturn V* booster followed by two successful manned Earth-orbital flights with the *Apollo* spacecraft. The fifth flight would then go to the Moon.

Test S-IV B Stage En Route to Cape . . .

First S-IVB upper stage of the *Saturn* launch vehicle is on its way from the Douglas Sacramento Test Center to Cape Kennedy, where it will be used to check out readiness of *Saturn IB* and *Saturn V* launch facilities. It began its sea journey, via the Panama Canal, last Thursday and is due at the Cape about July 2.

. . . And New Apollo Escape Test Approaches

Another *Apollo* escape system test is scheduled for June 22 at White Sands Missile Range, N.M. No *Little Joe II* booster will be used in the test, which will call for firing of the escape motor only.

Piland Due for New Post at MSC

Robert O. Piland, now deputy manager of the *Apollo* spacecraft project at Manned Spacecraft Center, is expected to be named to head a new office that will direct development of experiments for the *Gemini, Apollo* and *Apollo* Extension Systems (AES) at the center. A separate office will be set up to direct hardware work involved in MSC's role as manager of the AES spacecraft effort.

Patent Waiver Policy Change Deferred

NASA won a victory with the defeat of an amendment to the space agency authorization bill proposed in the Senate by Sen. Russell Long (D-La.), which would have removed Administrator James E. Webb's right to grant patent waivers in R&D contracts. However, other senators who opposed the amendment promised that a Government-wide patent policy —a matter which has been debated for decades—would be established this year.

Voskhod May Be Shown Off in U.S.

An informed Washington source reports that Soviet officials are considering shipping their *Voskhod II* spacecraft, used in the most recent Russian cosmonaut flight, to the United States to go on public tour.

INDUSTRY

Aircraft To Step Up Gemini Communications

Electronic Communications, Inc., has received an Air Force contract to establish a communication relay capability in two JC-130-A aircraft for use in upcoming *Gemini* flights. The planes will relay voice transmissions from the spacecraft to the ground and significantly increase *Gemini* communication efficiency.

Speculation on Leonov's EVA Performance

Industry life-support experts looking closely at slow-motion runs of the *Voskhod II* extravehicular experiment suspect that Cosmonaut Alexei Leonov may have had some kind of device to aid him in moving his joints. Some viewers noted what appeared to be a small box on the thigh of his spacesuit that he touched each time he prepared to move his arms. They conjecture that this might have lowered the air pressure in the upper torso of the suit.

Technology Program Value Questioned

NASA's technology utilization program is being labelled a "public relations gimmick" by some industry and academic observers. They point out that much of the material the agency compiles and mails—at considerable taxpayer expense —is of little value outside the aerospace field. And they note that although NASA has touted the program, the Tech Briefs carry the disclaimer that NASA makes no "representation, express or implied," with respect to usefulness.

INTERNATIONAL

U.K.-French Air-to-Surface Tests Succeed

Early test firings in the British-French program to develop a new air-to-surface missile system reportedly are going well. U.K. version is known as *AJ168*, and French as *AS-37*. Program was started last year by Hawker Siddeley Dynamics and Engins Matra. Britain's system, originally intended to go aboard the now-cancelled TSR-2, will be used on the Royal Navy's Buccaneer, and possibly on the F-111 if Britain opts to buy that aircraft. French version will go aboard the Mirage IV. Britain will use a TV guidance system being developed by The Marconi Co., Ltd., while the French are employing radar guidance equipment from Electronique Marcel Dassault. Missiles, with conventional warheads and a reported range of "tens of miles," may be operational in 1968-69.

British Offer Cheap Fair-Weather Mauler

U.S. officials are reported interested in a surface-to-air missile, the *ET316*, in development at British Aircraft Corp. The weapon is viewed as a possible fair-weather-only replacement for that portion of the all-weather *Mauler* system in the event that the latter missile is not deployed. The British system uses TV target tracking and a visually tracked missile, and a round reportedly costs about ⅙ as much as a *Mauler*.

Anglo-U.S. Laser Weapon Study Weighed

Possibility of a joint effort in assessing the capabilities of lasers as anti-personnel weapons is being discussed between the U.S. and Britain. Believed to be involved are studies with lasers using neodymium-doped glass. Anti-personnel use of lasers could involve blinding of enemy combat personnel.

Puzzle in French Probe Plans

Details of the Northrop-Ventura parachute-recovery system for the French *Super-Eridan* high-altitude rocket probe, released at the Paris Air Show, include the fact that the flotation gear will support 440 lbs. Gross weight of the Sud Aviation rocket's classified payload is estimated to be 750 lbs.

Solids Effort Cancelled

NASA has terminated the current $6.7 million 260-in. solid rocket demonstration contract with Thiokol Chemical Corp. because the motor case burst during hydro-test last April 11.

The case burst occurred considerably below its rated ability to withstand internal pressures, and subsequent studies by an industry-NASA team of experts pinpointed the cause to a weld failure—inherent to both the parent metal and the welding process used by Newport News Shipbuilding and Drydock Co.

The delay that would have resulted from proceeding with the Thiokol portion of the program would have slipped the test firing almost a year. Aerojet-General Corp. is now loading its 260-in. demonstration case. Both contractors used the same maraging steel for the cases, but different welding processes were deliberately chosen in the early portions of the program to more fully explore the possible routes to the huge motor case fabrication task.

The status of the large solid development program handled by NASA is unchanged at the moment —its future has been somewhat hazy for several years.

Nuclear Rocket Tests Urged

Atomic Energy Commissioner James T. Ramey believes that a decision is due on whether the U.S. is to go into full development of the nuclear rocket.

Ramey told an Associated Press regional meeting in Idaho Falls, Ida., last week that the U.S., to maintain preeminence in nuclear propulsion "should proceed aggressively in this development all the way to flight testing."

He pointed to the successes of the joint NASA-AEC Kiwi and NRX programs as justifying development.

With regard to the SNAP program, Ramey disclosed that an experimental SNAP-8 model completed a continuous test run of 209 days April 15.

Gemini Role Costs DOD Less

The Dept. of Defense is expected to spend less for support operations in NASA's *Gemini* program that was the case in Project *Mercury*, Lt. Gen. Leighton I. Davis, Air Force National Range Division commander, said last week.

Much of the reason for the larger expenditure in the *Mercury* effort was attributed to the "greater uncertainty involved" in the earlier *Mercury* launches.

DOD used the services of 18,000 personnel in Astronaut Gordon Cooper's *Mercury* shot—as compared with 10,300 DOD people in the *GT-4* space shot. *GT-4* deployment involved 26 ships and 134 aircraft, with the largest component being 4,800 Navy officers and men.

DOD Eyes Support Takeovers

The armed services are preparing plans for transferring support of many weapons systems programs from industry to DOD in-house effort. Extent of the move won't be known until the proposals are forwarded to DOD in about two weeks.

Industry-contracted technical services now totaling about $117 million per year are under consideration for the changeover. Total support services for United States military weapons systems worldwide are currently performed 57% in-house and 43% by contract employees, Robert C. Moot, Acting Deputy Assistant Secretary of Defense (Logistics Services), said. Secretary McNamara approved investigation of in-house support studies, observing that the armed services should become capable of maintenance and operation of weapons systems earlier in their life cycles. The services' study began in September last year.

Services of contracted technical personnel cost DOD an average of $16,220 per contractor man-year—as compared with $13,590 for a civil service man-year, and slightly less than the latter figure for military personnel performing these functions.

The studies showed that DOD could not do without training programs, data analyses and engineering services performed by industry during the introductory phase of weapons installation.

NAA Again Tops NASA List

North American Aviation, Inc., prime contractor for NASA's *Apollo* Command and Service Modules, continues to lead the list of industrial contractors to the space agency in net value of awards and percent of total awards to business.

NASA's most recent semi-annual procurement report shows that the California firm received 33.39% of the net value, or $796,825,000, in the first half of Fiscal Year 1965. NAA also placed first in percentage and value of awards for the entire FY '64.

The report also lists total NASA procurements for the first six months of FY '65 at $2.928 billion—$989 million or 51% more than awards for the corresponding six months of FY '64.

A big gap appears between NAA and the second-place Boeing Co. in percent of total awards to business for the first part of FY '65. Boeing received 9.77%, or $233,096,000. Boeing ranked fifth for the first half of FY '64.

The remainder of the top 10 contractors on the most recent NASA list follows, and includes their rank on the list for the first half of FY '64 (in parentheses), their percentage of total awards for the most current procurement period, and the dollar value of the awards:

Grumman Aircraft Engineering Corp. (6), 7.22% and $172,246,000; Douglas Aircraft Co., Inc., (3) 5.79% and $138,285,000; Aerojet-General Corp., (8), 4.27% and $101,804,000; General Electric Co. (9), 3.67% and $87,633,000; McDonnell Aircraft Corp. (2), 3.45% and $82,318,000; International Business Machines Corp. (10), 2.43% and $57,987,000; General Dynamics Corp. (4), 2.39% and $56,953,000; and Chrysler Corp. (7), 2.38% and $56,876,000.

Eighteen of NASA's 100 principal contractors during the period were small business firms, but only 5% of the net value of awards went to small businesses.

Full S-IC Firing Due Soon

NASA plans a full 2½-minute firing of the five F-1 engine *Saturn V* S-IC stage later this month.

Announcement of the first full-length firing was made last week, contingent on the success of a 90-second firing of the five engines which was scheduled for June 11.

A first attempt at a 90-second firing on June 8 was halted after 41 seconds.

Officials at Marshall Space Flight Center said there was nothing wrong with the static-test stage. The shutdown was blamed on faulty instrumentation, specifically a bad transducer which produced an erroneous signal that something was wrong with the stage.

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THERMODYNAMICISTS FOR SPACE AND RE-ENTRY VEHICLES

Several projects at Hughes require engineers qualified in fields of space vehicle thermal control or re-entry vehicle aerothermodynamics.

Projects include the Surveyor Lunar Landing vehicle, Syncom synchronous communications satellite, advanced anti-missile missiles and a number of classified projects. Applicants for space vehicle thermal engineering positions should have knowledge of radiation heat transfer; specific experience in the design of thermal control systems, surface treatments or thermal vacuum testing is highly desirable.

Re-entry vehicle thermal engineering positions require recent experience in hypersonic real gas dynamics; familiarity with heat shield design; re-entry observables and anti-missile systems requirements is desirable.

Advanced degree preferred with three to ten years' experience.

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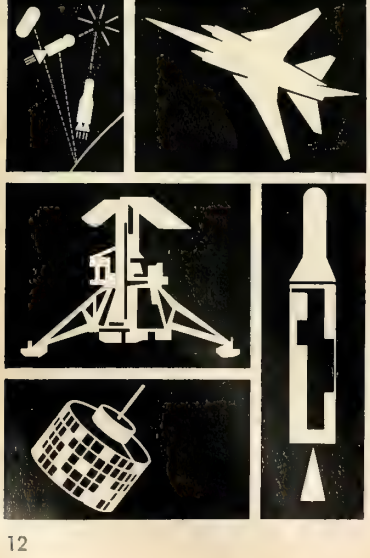


EVA Team Formed for MOL

Garrett Corp.'s AiResearch Manufacturing Div. and Bell Aerosystems Co. have teamed up to compete for the extravehicular, maneuverable portion of the Air Force's *Manned Orbiting Laboratory* program.

Garrett would be system manager for the EVA experiments. Bell would be responsible for propulsion, stabilization and attitude control.

ASMS Is In Trouble

With the Navy's *Advanced Surface Missile System (ASMS)* program continuing to exhibit thorny development problems, many of the industry contractors in the seven-company competition are convinced the effort is in serious trouble.

The program has already slipped a month or more beyond the projected target date for beginning the project definition phase, with no indication that DOD plans to authorize it soon. After an initial series of seven design proposal studies totaling about $500,000 each to Boeing, General Electric, Hughes, Sperry, Raytheon, RCA and Westinghouse in August, 1964, additional funding of about $90,000 each was given to each of the firms earlier this year to keep their technical teams together.

A 150-man evaluation group representing the Navy, industry and other technical personnel is disbanding and its report is due to be forwarded to DOD within about two weeks. Rear Adm. Frederic S. Withington returned from retirement to head the group.

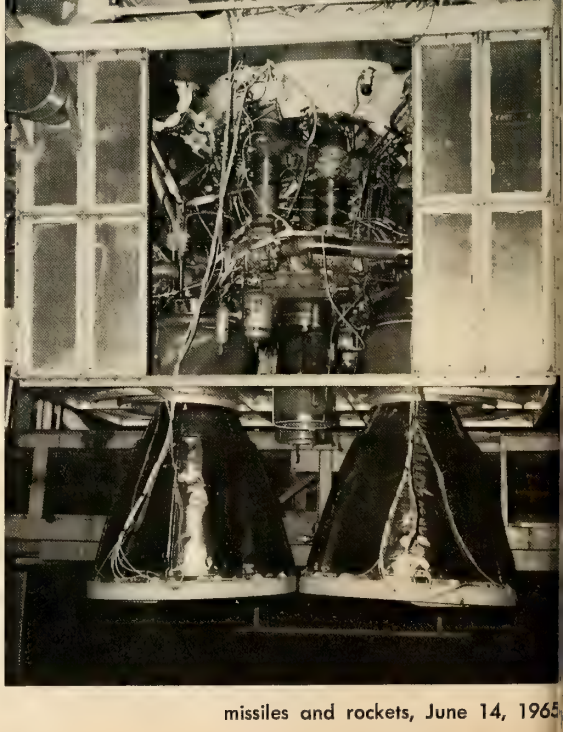
Informed observers note that, in the present state of the art, the *ASMS* effort is still plagued by major uncertainties, and there is no indication DOD wants to move to the PDP now. *Typhon*, a successor to the *Terrier, Tartar* and *Talos* concepts, was terminated in January, 1964.

Shots of the Week

The Air Force on June 8 launched the fifth and last in a series of cosmic radiation experiments from Cape Kennedy aboard a four-stage *Blue Scout* rocket. The rocket was to have reached an altitude of 12,000 n. mi. on a trajectory through the center of the inner Van Allen radiation belt and into the outer Van Allen region.

The 30-lb. copper cylinder payload housed four human tissue-equivalent ion chambers, two of them sensitive, and two insensitive, to neutrons. One of each type contained shielding of the type designed for use in the *Apollo* spacecraft. The use of tissue-simulating plastic in the ion chamber permits assessment of ra-

Fixture Simulates Titan III-C Boattail



AEROJET-GENERAL Titan III-C R&D engine in test fixture during recent firing tests at the firm's Sacramento, Calif., plant. Fixture simulates Martin Co. boattail that will support the engine in the booster's first flight test June 17. The preformed refrasil covering on the combustion chamber nozzles insulate the coolant tubes from the exhaust of the vehicle's two solid strap-on motors.

diation doses at various depths in the human body. Other instruments were to measure the number and energy of protons and electrons.

The payload also included a solar sensor to determine the payload's position in relation to the Sun and the Earth's magnetic field.

• The Soviet Union on June 8 launched the sixth *Luna* (formerly called *Lunik*) spacecraft on a path that was intended to take it to the vicinity of the Moon in 3½ days. *Luna 5*, which was launched May 9 (M/R, May 17, p. 14) and was to have soft-landed on the Moon, ceased transmitting when its retro-rockets apparently failed, causing the craft to crash on the lunar surface. *Luna 6*, described by the Russians as an "automatic" station, was launched from a satellite orbiting the Earth.

• The Air Force launched an *ABRES* re-entry experiment aboard an *Atlas* booster from Vandenberg AFB, Calif., June 8.

Milspec Library Opening

An archives service making available to industry superseded military specifications and other standard documents required in determining contractual obligations will become operational July 1 at the Navy Supply Depot in Philadelphia. The new repository will also be the single distribution point for DOD specifications. Records of approximately 20,000 cancelled documents are expected to be on hand when the facility opens for the first time.

Mobile Control Parts Sought

The Air Force Electronic Systems Div. has issued a pre-invitation notice for possible procurement of tactical air control system components, including six combat reporting posts to provide radar surveillance and control functions.

Included will be data processing equipment and displays, but no radar and communications elements. Procurement will be in two phases, a project definition phase, with two or more contracts to be awarded, and a second phase to include hardware procurement, with one contract awarded on the basis of proposals submitted by PDP contractors.

The notice was issued by the ESD 407L Systems Program Office, Hanscom Field, Mass., which is responsible for developing the Tactical Air Control System, a mobile communications and electronics system for command and control of deployed Air Force units.

Here's the Ledex wink in the eye of Mariner 4

The larger rotary solenoid in my left hand is one of our first models, developed some 20 years ago. The other one is a duplicate of the solenoid now in Mariner 4.

Its mission: to help take pictures of Mars on July 14.

Out there 134 million miles from home, it must trip the shutter of a TV camera 21 times at 48-second intervals. We are told that about 60% of the total mission success will depend on getting these pictures.

Since 1943, the Ledex Rotary Solenoid has been used for just about any type of snap action job imaginable. From ocean depths to outer space it serves defense in torpedoes, submarines, aircraft, missiles and rockets. It selects, arms, disarms, fires and guides. In industry it bolsters computer brain-power, automates complex machines, grips rugged truck brakes. It can pull, push, turn, twist, punch, trigger, index and hammer.

The Mariner 4 assignment is unique . . . with the 7-months' journey through the empty environment of outer space presenting conditions we cannot completely predict or simulate.

We hope, and believe, that on July 14—assuming all systems are Go—our solenoid will respond on command. It will pivot a precise 45°, trip the shutter and disclose to the world the first close-up of Mars.

Sincerely,

George H. Leland
Chairman of the Board

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Extravehicular Schedule May Quicken

Triumph of Gemini 4 also strengthens backers of military space activity; NASA cautious concerning EVA plans for GT-5 flight

THE SUCCESSFUL *GEMINI 4* flight has provided a selling point for a military manned spaced program and a basis for expansion of NASA extravehicular and other manned spaceflight goals.

The ability of astronauts James A. McDivitt and Edward H. White II to spot geographic landmarks and observe satellites in orbit around them fulfills one of the prime goals of a military program—reconnaissance of the ground and the space environment.

At the same time, the success of White's 20-min. walk in space is almost certain to spur NASA to additional extravehicular activity, perhaps as early as *Gemini 5,* such as having an astronaut retrieve experiments stowed in the spacecraft's adapter section.

Other possibilites are to have the astronaut go back to the adapter to determine how well he can work with tools, or use an expanded chest oxygen unit and a larger propulsion system being developed by the Air Force to maneuver for longer periods. And an early docking mission might be attempted with the *Agena* target vehicle.

Space agency officials declared that they doubt that they will change the flight plan for the seven-day orbital *Gemini 5* flight, because it "is ambitious enough as it is." But Robert Gilruth, director of the Manned Spacecraft Center, did not rule out changes in the flight plan, noting that "we always reserve the right to change these things if we want to."

One official did admit that further extravehicular operations were possible during *Gemini 5*—scheduled for August—but he would not say what type of activity might be undertaken.

In addition to the long-duration flight experience, the other major experiment planned for the next flight calls for the *Gemini* to rendezvous with a pod ejected from the spacecraft. The Rendezvous Evaluation Pod (REP), built by Westinghouse Electric Corp., consists of an L-band radar transponder, two high-intensity xenon flashing lights, and a power source for both. The rendezvous radar will be used to acquire and track the pod before the spacecraft moves to within 50 ft. of it.

Another possibility for *Gemini 5* is that NASA will launch the *Atlas/Agena* vehicle, which will be counted down simultaneously with the *Titan II* booster, and attempt to dock it with the *Gemini.* NASA officials deny this prospect, however, declaring that the countdown is simply a practice of the activities that will take place during the *Gemini 6* mission later this year, when the first docking mission is planned.

● **Few disappointments**—The speculation concerning future missions followed the highly successful 97-hr., 57-min., 49-sec. flight of the *Gemini 4* spacecraft. Launched at 11:16 a.m. EDT on June 3, the spacecraft impacted 450 mi. east of Bermuda at 1:13:30 p.m. EDT on June 7 after making 63 revolutions around the Earth. (A revolution begins every time the spacecraft passes over the Cape Kennedy longitude.) It landed 48 mi. short of the planned impact area, apparently because McDivitt fired the retro-rockets a half-second early.

Otherwise, the flight was marred only by the failure to rendezvous with the *Titan II's* second stage, a slight difficulty in closing the hatch after EVA, and a technical malfunction in the guidance and control system which rendered the on-board computer inoperative in the later stages of the flight.

Both command pilot McDivitt and pilot White apparently completed the mission with no evidence of deteriorating effects from the long period of weightlessness.

There was a slight indication of cardiovascular deconditioning in White, but this was below that suffered by Astronauts Gordon Cooper and Walter Schirra following their earlier orbital flights.

The rendezvous attempt with the Martin Co. *Titan II* second stage was scrubbed when too much of the Orbital Attitude Maneuvering System (OAMS) was used up trying to catch up with the stage earlier in the flight.

THE GEMINI-4 REPORT on these pages was prepared by NASA Editor Hal Taylor, Space Medicine Editor Heather M. David and Contributing Editor Jinx Mercer after on-the-scene coverage at Cape Kennedy and Manned Spacecraft Center, Houston.

White's trip into space took place during the third revolution. He spent 20 minutes propelling himself with a hand-held propulsion unit while being photographed by McDivitt from inside the cabin and by a camera mounted on the outside of the McDonnell Aircraft Corp. spacecraft. (For details of the two events see M/R, June 7, p. 14.)

The *Gemini 4* two-man flight was by far the longest U.S. spaceflight. Added to the previous 56-hour total for U.S. manned flights, the latest flight brought the total time for this country's spacecraft in orbit to 154 hours.

During the flight, the astronauts performed all 11 experiments planned for the trip. Final results of the experiments will not be known for some time because of the long, arduous task of breaking down the data transmitted from the spacecraft.

On two occasions during the flight, the astronauts reported sighting satellites in orbit around them. At the time, the closest satellite was many miles away. On one occasion, officials believed it was part of the *Pegasus* satellite which had been jettisoned shortly after it went into orbit. Two planned attempts to see *Pegasus* during its prescribed passes failed.

During White's EVA operations, he reported that he could see the coast of California, Galveston Bay and the Gulf of Mexico.

● **Two incidents**—Analysis of the two mishaps which marred but never threatened, the mission began almost immediately after recovery. The flight computer was removed from the spacecraft onboard the Wasp, and flown immediately to International Business Machines' Federal Systems Divisions, Space Guidance Center in Owego, N.Y. A team of engineers from IBM, NASA and McDonnell set to work immediately to examine it in detail.

The spacecraft itself was due Friday at the Cape, where McDonnell and NASA technical staffs planned to analyze the hatch problem. Although it was planned not to open the right-hand hatch—the one which would not close in the normal fashion when White reentered the capsule—it apparently was opened inadvertently on the carrier.

The computer problem was discovered during the 48th revolution, when during a routine check it was discovered

that it would not turn off. A malfunction light also appeared when the switches were used.

The problem was discussed with the *GT-4* crew, who suggested that the Acme switch be used to turn it off. This was referred to technical staff on the ground, who analyzed the situation and agreed that this might be a solution. The message to go ahead with the Acme switch was relayed to the crew as it passed over the Carnarvon, Australia, tracking station, and it was shut down. However, attempts to get it back on line brought forth only the computer malfunction light.

A similar problem had occurred during a simulation at McDonnell on *GT-2*. When the computer got too cold, it would not turn off. However, temperatures during the flight reportedly were measured far above this point, and the fact that the computer had worked perfectly many times at the temperature measured on *GT-4* cast doubt on this explanation.

Flight Director Chris Kraft also reported that a "glitch" had been noticed in the computer—a drop in amperage which it was feared might have caused internal damage.

With the computer ruled out after a number of in-flight tests, it was decided to go to a zero-lift re-entry, which would give ground control a better idea of where the spacecraft would come down, calculated on time and place of the initiation of re-entry. In this method, used in *Mercury*, the helicopters and ships have a jump of some 15 minutes to head for the recovery area. Without the computer, it would have been impossible to predict impact point if the usual lifted *Gemini* re-entry were attempted.

- **Hatch**—Why the hatch catch would not spring shut as designed remained somewhat of a mystery late last week. However, it did not affect the safety of the mission since design is such that it can be, and was, manually closed.

One theory was that a vacuum weld occurred in a spring-loaded catch. Engineers recalled that during checkout of the *GT-4* spacecraft, it was discovered that there had been a build-up of a dry-film, molybdenum lubricant on the device. This subsequently was "cleaned" off.

It was theorized that if it had, in effect, been scraped off too well, it might have left a surface exposed and permitted a vacuum weld. Another possibility was that the buildup was not entirely removed, and that it jammed the device. However, the manual back-up was successful with some effort, and when the catch was tested later in the mission—without opening the hatch again—it seemed to be operable.

- **Medical observations**—Preliminary

ABOVE: Astronauts observe from life raft while Navy frogmen move toward them after splashdown. Another frogman finishes attaching flotation ring to capsule. RIGHT: White (left center) and McDivitt are greeted on flight deck of USS Wasp by ship Capt. J. W. Conger (left) and Rear Adm. W. M. McCormick, commander, Carrier Div. 14, Atlantic Fleet. BELOW LEFT: Gemini 4 spacecraft aboard carrier. Heat shield in foreground shows heavy charring, but spacecraft is in generally good condition after 97-hr., 57-min. flight of more than 1,600,000 mi. BELOW RIGHT: White and McDivitt revisit spacecraft aboard Wasp.

WHITE PUSHES off from open hatch of Gemini 4 to start historic extravehicular activity on third orbit of trip.

ASTRONAUT uncoils umbilical line from its case (black object above him) in photo taken by command pilot McDivitt.

nary data indicate that the theory that in-flight excercise will help counteract the effects of prolonged weightlessness on the cardiovascular system has been borne out.

In tests on the carrier, there was some evidence of tilt-table response—White had a blood pressure of 145 over 94 and a heart rate of 96. When he was in the vertical position on the tilt table, his heart rate increased to 145-150. Dr. Charles Berry, chief of medical operations, described this as an "abnormal" tilt-table response. However, White experienced no faintness after undergoing these tilt-table exercises.

McDivitt's blood pressure—without the tilt table—was 136 over 88, with a heart rate of 88. Berry termed this "delightful." McDivitt's tilt-table measurments were not immediately revealed by NASA.

The indication was that although there was some evidence pointing to the orthostatic hypotension or deconditioning of the cardiovascular system previously noticed in Schirra and Cooper, the exercises performed in flight and/or perhaps a more careful attention to drinking enough water kept the condition down to less than that suffered at least by Cooper. Cooper experienced some dizziness on egress from the spacecraft on the carrier, and Schirra had a reddening of his legs indicating pooling of blood.

Tests performed by White, who stood up and sat down in the raft before the helicopter picked the astronauts up, also did not result in any fainting or dizziness. The astronauts also performed some leg-pumping exercises in coordination with blood pressures which were recorded on tape at the time. These tapes, together with the phonocardiogram measurements and bone-densitometry X-rays, have not been analyzed and released by NASA.

Otherwise, heart rates during the flight were well within ground expectation except for White's rather high 150 during the entire extravehicular operation and 178 just before coming back. At this period he had run out of fuel, and was working hard to maneuver himself. Blood pressures of both astronauts were slightly elevated during flight.

Land Recovery Likely to be Used For Final Gemini

SPACE AGENCY OFFICIALS are expected to approve a program calling for land recovery of the *Gemini 12* capsule at the end of the final flight in the two-man series.

Although a final decision is not expected for the next few weeks, one manned spaceflight official said the project probably will be given the go-ahead.

Charles W. Mathews, *Gemini* program manager at the Manned Spacecraft Center, would only say that an Earth recovery for the final flight is under serious consideration. He said that the decision would have to be made in the next few weeks because of the long lead-time certain items would require.

Mathews also said there had been no decision as to where the spacecraft would land if the program is approved. Among the contenders are the Southwest Texas area, White Sands Missile Range (N.M.), and Edwards Air Force Base, Calif. A primary and secondary site will be needed. Southwest Texas is regarded as the one site almost certain to be selected.

The Earth landing attempt would use the Parasail, currently under development by the Manned Spacecraft Center, to slow the speed of the *Gemini* capsule so that a soft touchdown can be made.

The project would require major modifications to the spacecraft, including relocating some equipment so that a landing gear could be installed.

Also, further development tests would be needed to man-rate the system. This would mean further drop tests with a *Gemini* spacecraft more representative than a simple boilerplate model.

A new display system for the astronauts would be necessary, as well as additional training equipment for the astronauts, including fixed-base and flight training.

It is expected that a control site will be needed for the actual landing areas.

The last flight in the series is tentatively slated for early in 1967.

LATER IN EXERCISE, White floats in space at end of tether more than 100 mi. above Earth's surface. Photo was taken by unmanned camera attached to spacecraft. Astronaut was persuaded to return to capsule after 20-min. excursion.

• **"Straw man" flattened**—White did become nauseated while in the spacecraft on the water, but this has been expected from preflight training exercises because of the bobbing of the craft in the water. No disorientation of any sort was reported during the flight by either pilot. Lack of disorientation by White during EVA knocked down one of the "straw men" anticipated in space, Berry said.

The 100% oxygen atmosphere created some red eyes during the first day or so of the flight, but the pilots appeared to become accustomed to it as time wore on. Some drying of the mucus membranes was noted after the flight, however, and McDivitt reportedly had a nosebleed on the carrier. However, absolutely no serious medical effects of any sort were noted, NASA said.

Calorie intake, which was programmed at 2,500-2,600 per day, fell about 500-700 calories under this target. Although the astronauts experienced no hunger during the flight, they reportedly complained of hunger upon recovery. Water consumption also was down in the first days of the flight, but after repeated urging by Dr. Berry and other medical monitors, the astronauts drank enough water to keep from being seriously dehydrated.

No psychological problems or irritability, either with one another or with ground crews, was noted. Berry said that some "householding problems" had been anticipated by the medical operations staff.

Sensors for biomedical data, which caused some skin irritation in *Mercury*, caused little in this flight, and no more for the four-day flight than the three-orbit *GT-3*.

• **Life support system**—Capsule designer McDonnell Aircraft Corp. and life-support equipment contractor AiResearch Manufacturing Division of the Garrett Corp. received high praise from NASA for the spacecraft atmosphere system.

Temperature within the capsule stayed at an average of about 70°F, with relative humidity a comfortable 50-65%. Re-entry temperature was 70°, and suit inlet temperature on the water 50°.

The performance of the cabin atmosphere water removal system gave great encouragement to Manned Spacecraft Center officials, who had feared that special equipment would have to be designed for *Apollo* flights. In fact, a small contract was let to AiResearch to develop a simple silica gel/vacuum removal humidity control unit. This device, due at MSC next month, is *Gemini* flight equipment developed in the event that humidity proved to be a real problem.

That the humidity remained at such an unexpectedly low level was partially attributed to the fact that oxygen flow rate through the cabin was slightly higher than normal because of a slight heating in the cryogenic oxygen supply.

Rather than use the relief valve, the crew was instructed to allow cabin pressure to build up slightly higher than normal. At some points it reached about 5.5 psi. However, it was held just short of the point—about 5.7 psi—at which the cabin relief-pressure valve would have opened automatically.

Pressure in the two systems was juggled throughout the flight in this manner, producing a higher flow rate.

Operation of the waste collection systems was generally satisfactory, except for leakage of urine into the cabin as was experienced in *GT-3*. Toward the end of the flight, McDivitt told the ground control that "I thought those fumes around 24 hours were bad. You ought to be up here now!" ■

Optical Rendezvous Now Favored for LEM

HOUSTON, TEX.—Project *Apollo* officials now favor optical rather than radar rendezvous methods for the *Apollo* spacecraft's Lunar Excursion Module.

The optical system is now being studied by three contractors in a parallel development effort with the radar system being developed by RCA. The three firms with four-month study contracts are Perkin-Elmer Corp., Itek Corp. and Hughes Aircraft Co.

Later, one contractor is expected to be selected to actually develop the system, if it appears to be feasible. A final decision between the radar and optical systems is expected late this year.

Radar rendezvous systems were deleted from the *Apollo* Command and Service modules about three months ago.

Dr. Joseph Shea, director of *Apollo* spacecraft development at the Manned Spacecraft Center, said that "we have become increasingly enamored with optical rather than radar rendezvous."

Optical systems, he continued, appear to be simpler and to weigh less.

AF Confirms ICBM Improvement Drive

Ballistic Systems boss Sands reports progress in programs to boost Titan II payloads, develop new Minuteman re-entry vehicles

by Donald L. Zylstra

FOR THE FIRST TIME last week the Air Force publicly and officially confirmed some of the ballistic missile improvement efforts now under way to increase the penetration capability of its *Minuteman* and *Titan II* systems.

Research and development efforts already in the pipeline include "subsystems which can feed back information to our control centers concerning the success—or failure—of a combat mission," Brig. Gen. H. J. Sands, Jr., commander of the Air Force Ballistic Systems Division, told a meeting of the Aviation/Space Writers Association (AWA) in New York City last week.

Two efforts to improve *Titan II* capabilities are of special significance.

"Present work in chemical propellants foreshadows some of the most significant breakthroughs of the near future," Sands said. "We are investigating storable metallic thixotropic fuels—in which the propellant is jelled to keep the metal powder in suspension—which combines some of the best properties of both solid and liquid cryogenic fuels. These propellants, if substituted for present *Titan II* propellants, could double the payload capability that can be delivered from *Titan* silos."

Other developments in the search to materially increase *Titan II* payloads with only minor modification of existing silos include exploring adaptation of the Navy's *Polaris* "cold launch" technique to fixed-base missiles.

"The payoff of such an application could be tremendous, permitting the launch of greatly increased payloads from existing silos," Sands said. Both *Polaris* and the Army's *Sprint* missile lift out of their tubes or silos before ignition of the chemical propellants.

Sands said no one should assume that the United States is currently taking a "breather" in ICBM R&D—or, indeed, that this will ever be possible in the foreseeable future. Propulsion, materials, guidance and re-entry technologies are all receiving heavy emphasis in attempts to keep well ahead of potential enemy threats.

● **Four threats**—Destructive forces which threaten a ballistic missile system divide themselves into four main categories, beginning during storage and lasting through re-entry.

While the missile is stored within its silo, Sands noted, "major damage can be done . . . by blast, earth movement, electromagnetic effects, radiation and falling debris." Once the missile has been launched, ground shock is no longer a problem, "but air blast, radiation and thermal effect are all potential hazards."

As the missile coasts outside the atmosphere in its ballistic phase, blast effects are non-existent, "but a nuclear attack could subject the missile to harmful X-ray and gamma pulse interference. In hardening a weapon system against these threats, we must achieve a balanced hardening that leaves no Achilles heel to be exploited by an enemy," Sands said.

Once missiles have managed to survive through this set of hazards, they still face maximum uncertainty and danger in the final phase of their trajectories—re-entry and penetration to target. "A host of natural and man-made hazards threatens the re-entry vehicle as it hurtles at better than 20,000 feet per second (through) the approximately 300,000 feet down to impact," Sands said.

The Air Force is developing three different re-entry vehicles for eventual use with *Minuteman*, Communications package developments for *Minuteman* are currently under way "to tighten the necessity for an enemy to target the individual launchers, rather than the launch control center, thus multiplying the number of enemy missiles required to take out a *Minuteman* flight," Sands said.

The Ballistic Systems Division chief emphasized that definition of *Minuteman* force modernization and a changeover to *Minuteman II* "does not mark a freezing of *Minuteman* research and development."

"A number of programs are in progress which have as their objective increasing *Minuteman* invulnerability to attack both in the silo and while the missile is on its way to the target. Many additional improvements will undoubtedly be incorporated into the *Minuteman II* system before progress in the force modernization program forces a final freeze on changes . . ."

● **Titan II, too**—Sands cited the importance of the six squadrons of *Titan II*, totaling 54 launchers. Noting that *Titan II* has extreme range, with the heaviest of all U.S. ICBM payloads, Sands said. "Present developments sharply reaffirm the importance of our retaining this capability. The trend toward greater sophistication of re-entry vehicles inevitably means heavier payloads and places a premium upon the capability to deliver such weight to a wide variety of distant targets."

In materials technology, Sands noted that the Air Force has "struck some rich veins." Three significant breakthroughs in this area include development of oxide dispersion-strengthened metals; new metalloid fiber techniques; and new families of organic and inorganic polymers. "We are pushing and would like to see further rapid developments in high-efficiency heat-shield materials, materials with special shielding properties against various forms of radiation and materials which combine light weight with minimum radar observability."

By investigating aids to basic inertial guidance systems, such as radio and stellar tracking, DOD hopes for a potentially high payoff in mission effectiveness. "The payoff here is roughly ten to one," Sands said. "That is, if we can improve our accuracy by a factor of 10, we increase the effectiveness of our firepower by a factor of about 100."

The *Advanced Ballistic Re-entry System* (*ABRES*) program is a BSD responsibility, with the mission of developing new re-entry techniques for all of the armed services. One of its aims is making a missile's radar and optical signature "so small that an enemy's defense system will fail to detect it—at least until it is too late for interception. We can take an object the size of a standard dining table and make it look like the end of a pencil to a detection radar system," Sands said.

Other promising techniques involve deceiving or overpowering enemy radar; development of a maneuvering capability, making possible a "flexible mix" of standard and maneuvering vehicles; and use of a single missile to deliver multiple re-entry bodies.

Re-entry observations from Eniwetok Island in the Pacific have already demonstrated three-stage missile re-entries (presumably *Minuteman*) as "predictable as a milk train," plunging into a designated lagoon area "precisely where the three cameras were triangulated on it," Sands said. ■

New Push for Extra Apollo Funding

Rep. Teague may discuss financial situation with NASA chief Webb; he reiterates concern that delay in MOL decision may wreck Gemini team

THE QUESTION of whether NASA should ask for supplemental funds to spur the *Apollo* lunar-landing program again was renewed with the success of the *Gemini* flight last week. Rep. Olin Teague (D-Tex.), pointing to the momentum in the space program caused by the flight, indicated he would discuss with NASA Administrator James E. Webb a request by the agency for a supplemental FY '66 authorization of perhaps $200 million or more.

The House Space Committee member indicated his feeling that NASA is "dragging its feet" on this, because of its fear of getting turned down by the Budget Bureau. However, he said he felt quite strongly that *Apollo* does not have enough money.

Although he termed *Gemini's* financial situation, as far as NASA is concerned, as "fat," he again expressed his extreme concern that the future of the *Gemini* program will be marred by postponement of a definite decision by DOD on its plans to use *Gemini* for the *Manned Orbiting Laboratory (MOL).*

He pointed out that the last *Gemini* capsule is coming down the line at McDonnell, and that the highly successful manufacturing team and its subcontractors are in danger of being dispersed without a definite answer.

Teague expressed this concern in a letter to the President which, through Vice President and Space Council Chairman Hubert H. Humphrey was answered by Secretary Robert S. McNamara and Webb. In this exchange, McNamara made it quite clear the possibility still exists that after the internal NASA and DOD surveys of the two approaches available—through use of *Apollo* or *Gemini*—and the contractor studies, a decision could still be made not to proceed at all.

Although McNamara has indicated that he does not expect this conclusion, he has made it clear that the Air Force must justify that the military value will be commensurate with MOL's cost.

McNamara gave assurance that full use will be made of the skilled people now associated with *Gemini* no matter which hardware approach is selected, should he decide to proceed. Webb also revealed that a plan has been given DOD which would utilize skills developed in the *Gemini* program.

However, the contractor team which might be broken up before a decision is made include those at Rocketdyne, Honeywell, Westinghouse, International Business Machines, Northrop, Collins Radio and Motorola.

● **Apollo Extension System**—Teague said he was disturbed at the action of the Senate some weeks ago in cutting the $48 million asked for the *Apollo Extension System* by one half.

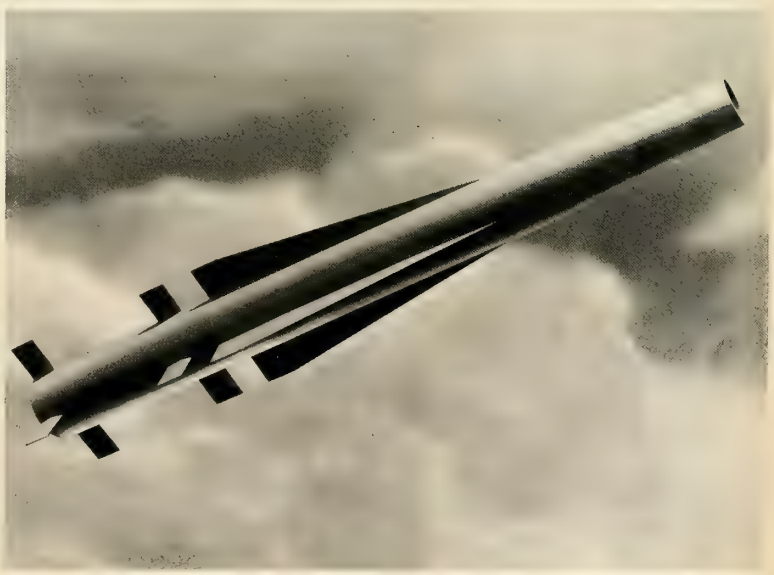
House Space Committee members met last week to map their plans for a conference with Senate Space Committee members late in the week, to work out differences in the two bills. The House bill calls for $76 million in cuts. The Senate cut $63 million.

However, House cuts occurred in *Apollo, Orbiting Geophysical Laboratory, Orbiting Astronomical Observatory, Surveyor,* Launch Vehicle Development, and in construction funds for the Electronics Research Center. The House voted to add funds for the M-1, SNAP-8, and 260-in. large solid rocket programs.

The Senate's reductions came from *Apollo Extension Systems, Orbiting Astronomical Observatory,* launch vehicle procurement, technology utilization, construction at Kennedy and Manned Spacecraft Center. However, it did not add funds to the M-1 and SNAP-8 programs, going along with the House only on the 260-in. solid.

NASA Administrator Webb will testify before the Senate Independent Offices Appropriations subcommittee this week. He will attempt to get back from this committee part or all of the money cut by the House Appropriations Committee, which amounted to only $37 million more than the House cut, or $23 million more than the Senate.

GT-4's performance should make the work of space-conscious Congressmen easier, Teague indicated. Presumably, it could head off the announced intention by Sen. Joseph Clark (D-Pa.) of offering an amendment on the Senate floor to cut the appropriation further. ■



First Photo of Britain's Sea Dart Design

STILL IN R&D PHASE, Britain's Sea Dart missile at present has this design configuration. Prime contractor Hawker Siddeley Dynamics released this first photograph of the weapon, for which it has been funding an in-house study for about a year. Firm hopes to sell a land-based version to U.K. or NATO.

U.K. Polaris Program on Schedule

First operational submarine to go on station three years hence; Poseidon not expected to be ready for four-boat contingent

by Robert Lindsey

LONDON—The United Kingdom's version of the *Polaris* Fleet Ballistic Missile program, featuring some unique British contributions in submarine design, is on schedule and thus far has been remarkably free of serious difficulties, says Vice Adm. Hugh Stirling Mackenzie, British *Polaris* program executive.

"We're on the time scale originally laid down," Mackenzie told MISSILES AND ROCKETS in an exclusive interview. "We expect to deploy our first operational submarine in mid-1968 and the other three at six-month intervals after that."

Asked if Britain is interested in the *Poseidon* missile, the fourth-generation *Polaris* system now in the Program Definition Phase, Mackenzie said "there is always that possibility." But he stressed that the current program is focused solely on the *Polaris A-3*. He noted that British submarines, like later classes of U.S. *Polaris* vessels, are designed to accept advanced launching systems with minimum difficulty. *Poseidon*, however, is not expected to be available by the time the British subs become operational.

Mackenzie emphasized that British *Polaris* submarines are to be of hybrid U.S.-British design. The weapon section of the subs will be a "carbon copy of your submarines with no British modifications," while the front and rear portions will be of purely British design, he said.

For her four subs, he said, Britain is receiving the most advanced weapon-system components from the 627 class of *Polaris* submarines. American contractors are supplying, in addition to the missiles, the *Polaris* fire control systems, SINS (ships' inertial navigation system) and steam-gas launching systems.

● **Touch of RN**—He made it clear that the British aren't blindly following American submarine design. For example, they are using bow diving planes in the traditional British style instead of diving planes on the sail in the style of American *Polaris* subs. And, he noted, the British atomic reactor and propulsion system are also quite different.

Physically, the U.K.'s submarines will be about the same size as the Lafayette class of U.S. Fleet Ballistic Missile submarines, with a length of about 425 ft. and a 32-ft. beam.

For the most part, he said, British electronics are being employed in the non-*Polaris* portions of the submarine, such as sonar and electronic countermeasures. However, a small amount of the equipment probably will be purchased from America.

Although British will use American-built Lockheed *Polaris* missiles, they will carry British warheads with "about the same bang" as U.S. *Polaris* warheads. Mackenzie declined to say whether American penetration aids will be used, but other sources indicated it is highly likely.

Mackenzie placed the total systems cost of the British submarine force at $1.1 billion, including the four ships, missiles, the new shore base under construction in Scotland on the River Clyde near the U.S. *Polaris* moorage at Holy Loch, logistics and other support costs.

● **Smooth sailing**—Despite the apparent difficulties of integrating the complex elements of the *Polaris* system into submarines designed and built in foreign shipyards, the U.K.'s *Polaris* program has encountered no serious difficulties, Mackenzie said.

He attributed much of the success to a streamlined system of communication between British and American advisers here that has enabled difficulties to be resolved at the project officer level. A Joint Steering Task Group, chaired by Mackenzie and Rear Adm. Levering Smith, chief of the U.S. Navy Special Projects Office, meets quarterly to resolve problems. But in virtually all cases, the problems have been resolved before these meetings, he said.

"There are queries flying back and forth all the time. We don't wait for these meetings to crop up," Mackenzie said. "I think this has been one of the remarkable things—the speed we have developed in talking and solving difficulties."

Most of the problems here have been non-technical, officers said, including differences in U.K. and U.S. accounting procedures, keeping funds moving at the right speed and, in day-to-day experience, the differences in American and British use of the English language.

Capt. Patrick Murphy, U.S. Navy Special Projects Office senior representative here, said, "We have had problems, but the whole program has worked exceptionally well. Where we have had differences of opinion, we have been able to resolve them and get on with it."

Pressed for areas where there have been more difficulties than others, Mackenzie said "we are having the most difficulty keeping on target in the shipbuilding area." He did not give details, but the British press has reported various labor shut-downs have hampered the submarine program. Technically, Mackenzie said, the British workers are doing as well as Americans. In welding technology, for example, he said, "I think our people are doing better than you're doing."

The obvious area where problems were foreseen, he continued, was in component interfaces. In the initial phases of the program, however, precise mechanics were established for joint control over component dimensions to assure interface compatibility, and they have been "very carefully maintained," he said.

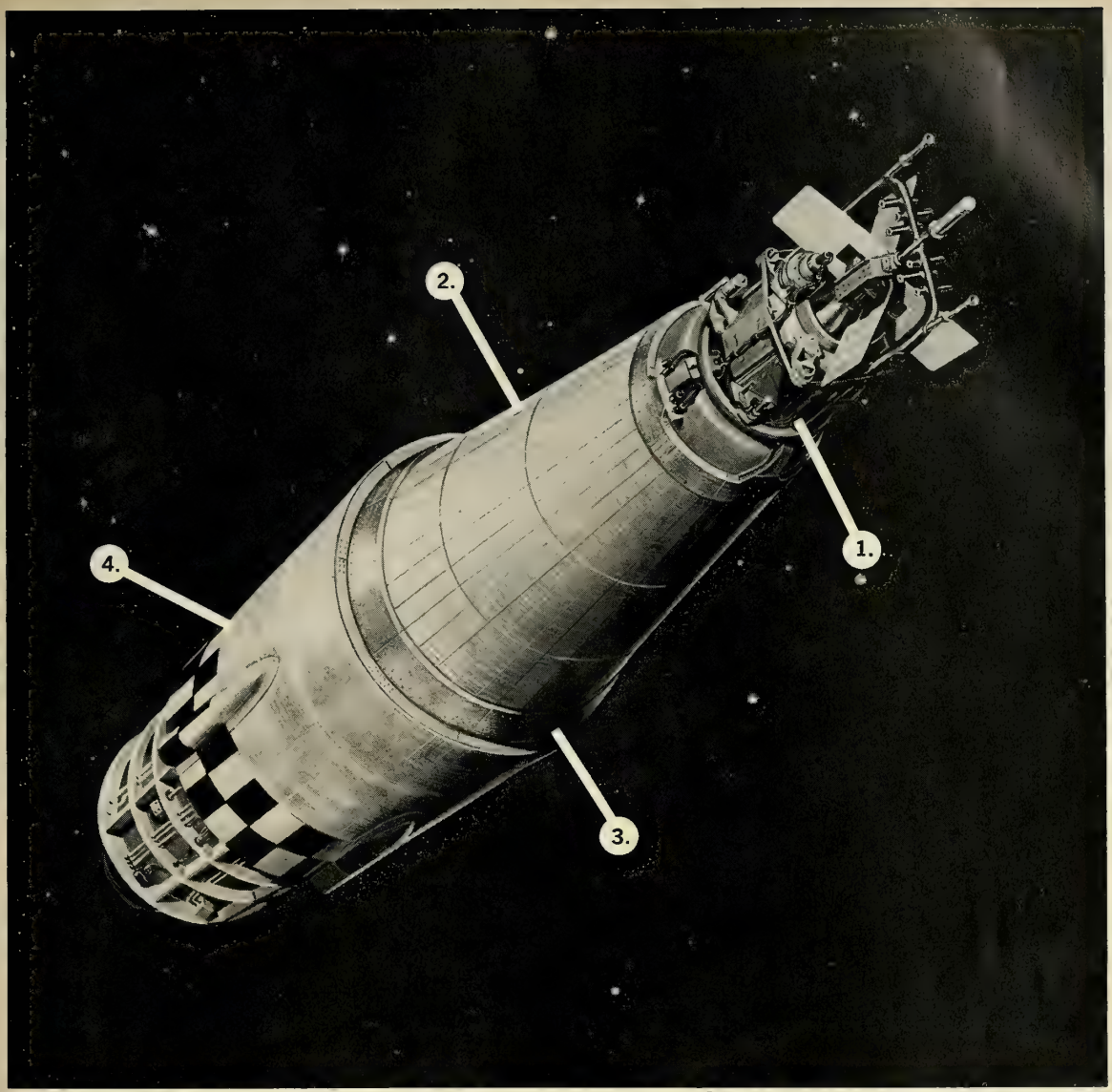
● **Early-on independence**—The first and third British submarines are being built at Barrow-on-Furness by Vickers-Armstrong Ltd., and the second and fourth by Cammel-Laird Ltd. at Birkenhead. About 800 British firms are participating as subcontractors.

Fewer than 25 U.S. Navy personnel are working on the program in Britain, all in "advise and assist" capacities, Murphy said.

It is clear the Britons want to make their *Polaris* program independent of American support as soon as possible. By the time initial crews are graduated by U.S. *Polaris* schools, "we should virtually stand on our own feet," although there will be a continuing acquisition of some components from U.S. contractors, Mackenzie said.

Operationally, the British submarines will deploy from the new Royal Navy *Polaris* base at Couport, about 15 miles from the U.S. moorage at Holy Loch. No advanced tender will be used.

Mackenzie declined to answer questions on operational plans for the British submarines, particularly on the extent to which they might be informally integrated into the U.S. fleet. However, it appears clear that while there may be joint consultations on targeting of the missiles, Britain will operate her submarines independently of the U.S. fleet, unless, of course, Prime Minister Harold Wilson fulfills his one-time promise to turn the submarines over to NATO control. ■



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Technical Countdown

CRYOGENICS

NBS Closes Low-Temp Scale Gap

A new low-temperature scale for the region between 4 and 14° Kelvin has been established by the National Bureau of Standards. Based on the acoustical thermometer, it is an absolute scale bridging the gap between the two previously established scales that left the 5-10°K region open. Thus, said NBS, industrial standard thermometers can now be calibrated at 1-degree intervals from 2° to 20°K. The first calibration just recently completed served as the culmination of a successful 9-year research effort to provide a full scale below 20°K. NBS temperature-measurement continuity now extends from 2°K to 1,063°C. (Above 1,063°C, temperature t is defined as the ratio of the spectral radiance of a blackbody at temperature t to the spectral radiance of a blackbody at the gold point, 1,063°C.)

Superfluid Gyros Demonstrate Coastability

Day-long, or even longer, gyroscopic operation may be possible without use of sustaining or boosting energy, according to two papers recently published in *Physical Review Letters* by J. B. Mehl and Dr. W. Zimmerman, Jr., of the University of Minnesota and by Dr. J. D. Reppy of Yale. A closed circular current of liquid helium II (—271°C) was used in the two separate research projects to replace the more conventional gyro's spinning wheel. Reppy employed the superfluid in an annular gyro while the other two scientists worked with a spherical gyro filled with silica powder. Zimmerman and Mehl demonstrated the ability to change a super-current angular momentum by slight temperature change (momentum increases as temperature is decreased). Typical speeds obtained were 1/20 revolution per second with coast times of up to several hours.

ELECTRONICS

Improved Gravity Field Data Sought

The Army is interested in development of satellite instrumentation that would permit better mapping of the gravity field above the Earth so that the results can be applied to missile trajectories. Observations of near-Earth satellites have been used to supplement terrestrial measurements, but these suffer from unequal distribution, according to spokesmen who say that a major development for satellite application would be required because of the weight, bulk and other undesirable features of current gravimetry instruments. The instrumentation could be incorporated to provide a combination *SECOR-Gravimetric* satellite.

MATERIALS

Metal-Film-Lubricant Interest Grows

Scientists at Elliott Automation's Space and Weapons Research Laboratory in England report that recent tests in a continuing research program for improving bearing lubricants for space system use have encouraged interest in soft-metal (lead) films. Of 65 bearing-pairs mounted in individual, relatively simple, glass-encapsulated test rigs, 35 pairs are still running, with one pair having achieved 10,000 hours of continuous operation (2 x 10^9 revolutions) at 10^{-11} torr and under a light axial load of 260 grams. Other pairs have exceeded 4,000 hours and are still running. Results to date using three different film application methods indicate better performance for electroplating than for friction-coating and about equivalent performance between vapor deposition and electroplating techniques, although the latter is easier. Bearings used are 6-mm, angular-contact, tool-steel types. Low frictional torques (0.003-0.006 oz.-in.), believed better than those achievable with good oil lubricants, appear to accompany the use of lead film, Elliott disclosed.

Light-Gas Gun Tops Mach 40

Possibly the highest known speed in a light-gas gun counterflow system, 43,000 fps, or nearly 30,000 mph, was attained recently by NASA's Ames Research Center. This corresponds to an actual Mach number of 24 because the gas is heated to 2,000°F, but is considered equivalent to Mach 40 from the point of view of heat-transfer simulation. The speed was achieved with a gun speed of 37,000 fps and a counterflow air speed of 16,000 fps.

Purest Salt in History at Westinghouse

A technique developed by Dr. R. W. Warren of the Westinghouse Research Laboratories yields 2-ft.-long crystals of potassium chloride with impurities less than 10 parts per billion. The extremely pure samples are 0.5 in. across and far more transparent and colorless than the clearest glass. The simple, regular structure of the zone-refined crystals are being used to study crystalline state phenomena such as light absorption, fluorescence, electrical conductivity and magnetic properties. The crystals are grown in a concentric quartz tube arrangement using an acid atmosphere. The outer tube is wrapped with nichrome heating wire and the heat is concentrated in a zone across the salt-filled inner tube by a moving firebrick arrangement. Each pass requires some 12 hours, and 10 passes are needed for complete purification.

PROPULSION

LEM Helium Pressure Vessels Ordered

Electrada Corp., Culver City, Calif., will fabricate 100 titanium helium storage vessels for the Lunar Excursion Module's ascent and descent engine pressurization systems under a $1,155,000 contract from Grumman Aircraft Engineering Corp. Order includes fifty 23-in.-diameter vessels for the ascent system and fifty 33-in.-diameter vessels for the descent stage. Prototype hardware is scheduled for delivery in about two months, with production hardware expected in four months.

SPACE MEDICINE

Manakin Tests Spacesuit Capabilities

A power-driven articulated dummy that can simulate almost any human action has been delivered by ITT Research Institute to NASA's Manned Spacecraft Center for use in measuring spacesuit capabilities. The anthropomorphic dummy, powered by hydraulic actuators at 35 joints, is equipped with sensors at each joint to indicate the amount of force needed to make each movement in the pressurized suit. The manakin weighs 230 lbs. and can be adjusted from 5 ft. 5 in. to 6 ft. 2 in.

Corrosion Hampers AF Development

Comprehensive materials symposium also indicates that lack of definitive test procedures is a major obstacle to progress

by John F. Judge

MIAMI BEACH, FLA.—Corrosion in its broadest aspects and the lack of definitive tests in all areas of materials technology are the two largest problems facing the Air Force in performing its currently assigned missions.

A cross-section of the aerospace industry and its hundreds of allied subcontractors was exposed to Air Force problems in materials last week in the most comprehensive and detailed coverage of the technology in recent years.

The occasion was the 1965 Air Force Materials Symposium, sponsored by the Air Force Materials Laboratory, Research and Technology Division, Air Force Systems Command, Wright-Patterson AFB, Ohio.

Air Force experts from the Materials Lab covered every area of materials technology, describing the state of the art and improvements since the last symposium in 1961 and projecting the service's needs over the next five years.

● **Major operational headache**—Just how serious the corrosion problem is within the operational segments of the Air Force is indicated by the statement that most primary structural failures of AF systems have been caused by stress-corrosion cracking of forgings or extrusions.

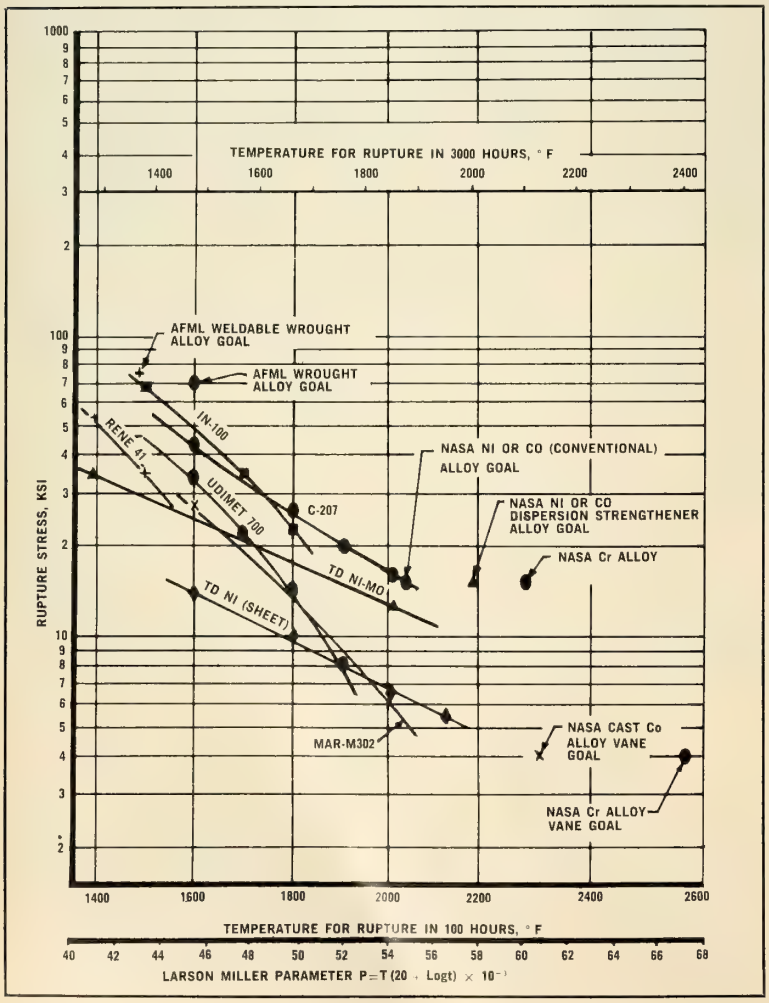
The testing problem and its attendant area of developing design criteria were illustrated by the catastrophic failure of a bomber in flight due to the initiation of a small fatigue crack at a rivet hole in a lower wing panel. Had data been available to the designers prior to the selection of material for these wing panels, millions of dollars and several lives would have been saved.

Specific areas of corrosion problems were covered by C. Bradley Ward and Bennie Cohen during the Corrosion Panel. After discussing materials compatibility with rocket propellants, the Materials Lab experts said there still is a corrosion problem in missile silos. This is caused by the aggressive atmosphere, hydrogen-sulfide contamination, water leakage, insufficient drainage, exhaust fumes, condensation, dissimilar metal contact, inadequate metal surface preparation—and other items, such as coatings and lubricants.

All of these factors have combined on occasion to render control devices inoperative, develop leaks in containment vessels and seize shafts.

● **Stress corrosion**—Stress corrosion and the subsequent cracking caused by its presence is a major problem in operational equipment. Ward and Cohen covered specific problems with aluminum, high-strength steels and titanium and their alloys.

The authors noted that a major source of failure in aluminum is use of closed-die forgings. The rework pro-



cedures for aluminum stress corrosion in service vehicles is removal of the surface finish, inspection, shot peen and re-coat.

Ward and Cohen said it has only recently become apparent that high-strength low-alloy martensitic steels are susceptible to stress-corrosion cracking. Work is being funded to handle this problem.

Ward and Cohen cite another problem—termed insidious rather than spectacular. This is exfoliation corrosion, in which metals exfoliate or delaminate in the skins around fastener holes.

The corrective action is to use wet fittings—install the fasteners with wet sealant or zinc chromate primer at the time of manufacture.

The authors claim that the attempt to control corrosion on operational vehicles is an uphill battle—the real key is to incorporate corrosion-preventative measures in actual manufacture.

Research on preventing high-temperature corrosion will continue to be strongly emphasized by the Materials Lab. The trend is in the direction of coatings operable above 3,000°F and coating for long-time lower-temperature exposure—e.g., in turbine buckets.

Efforts to advance current coatings are centered around improving their multi-mission or re-use ability.

O. O. Srp told the symposium that no non-destructive inspection technique to date has shown any more validity than visual examination by an experienced inspector for assessing the reliability of current coatings.

"The problem," he says, "lies not so much with the NDT methods themselves as with the inability to describe quantitatively the defect that will or will not be a potential point of failure."

The development of superalloys—including chromium-base alloys for the advanced turbine engine applications—is in a state of flux, at least in the area of fixing compositions and mechanical properties for the purposes of marriage with coatings.

Somewhat more emphasis is being given to TD Nickel—since it is the material in evidence for higher-temperature guide vanes and other low-stressed applications in turbine engines. Modifications of the aluminide-type coatings are showing initial promise.

• **Technology surpasses tests**—The testing problem runs all through materials technology. A sampling of the testing headaches cited by the various Materials Lab experts during the symposium includes the following:

—*Composites*—There is a need for establishment of industry-wide, standard test methods. In particular, tests are demanded where the strength properties of unidirectionally reinforced test-pieces and structures are to be determined.

The difficulty in the composite-test area is that designers themselves are not in agreement as to the kind of design data required for a given application. Secondly, there is no comprehensive knowledge of the functions of the component materials in a reinforced plastic, their interactions or mechanism of failure—either during destructive testing or usage.

Another problem is the determination of which tests are applicable to materials comparisons and which applicable to design problems.

—*Fibrous materials*—While current techniques are suitable for the materials being researched, improvements must be made to handle the next generation of fibrous materials. New methods of characterization must be forthcoming to offset the limited ability of current techniques. For example, a current test to determine the critical velocity of yarn involves firing a notched .22-cal. bullet which engages and ruptures a test yarn. The bullet pierces a tinfoil strip prior to hitting the yarn, which triggers at multimicroflash unit to record the impact data.

—*Polymeric protective coatings*—Conventional methods previously used to evaluate such coatings can no longer supply all the necessary information. There is a demand for new and novel methods, together with additional techniques for characterizing these coatings as newer and more stringent requirements are placed on the coatings.

—*Design criteria and test techniques*—C. L. Harmsworth, of the Applications Div. in the Materials Lab, generalized the entire testing problem within the Air Force. "The major problems associated with our inability to design a completely efficient component which is neither over- nor under-designed are functions of our ignorance in many areas," Harmsworth said.

"These include our lack of knowledge to adequately analyze complex loads and geometries associated with aerospace systems. There is an inability to simulate the complex histories of temperature, stress, time, gases, liquids, radiation and various combinations of all of these."

• **Fiber composites**—Air Force expectations in boron fiber properties have come very close to realization. The fibers have a modulus of elasticity averaging about 55 x 10^6 psi—with individual values that run as high as 64 x 10^6 psi.

The density of such fibers is about 2.5 g/cc for 5-mil diameters and the "as-formed" strength on a routine repetitive basis is about 400,000 psi. Problems in fabricating parts from these stiff fibers have been anticipated, and AF spokesmen are optimistic in this area.

While boron is the magic material, research is being funded in deposition-formed, continuous fibers of the carbides, borides, silicides, beryllides, nitrides and oxides.

Glass fibers currently have no equal in the field of structural composite reinforcement, says W. H. Gloor of the Materials Lab. But research is being pushed to further increase the physical property levels attainable with glass fibers.

These compositions lie in a higher temperature regime than the present

Ceramics and Graphite Information—A Plea for Help

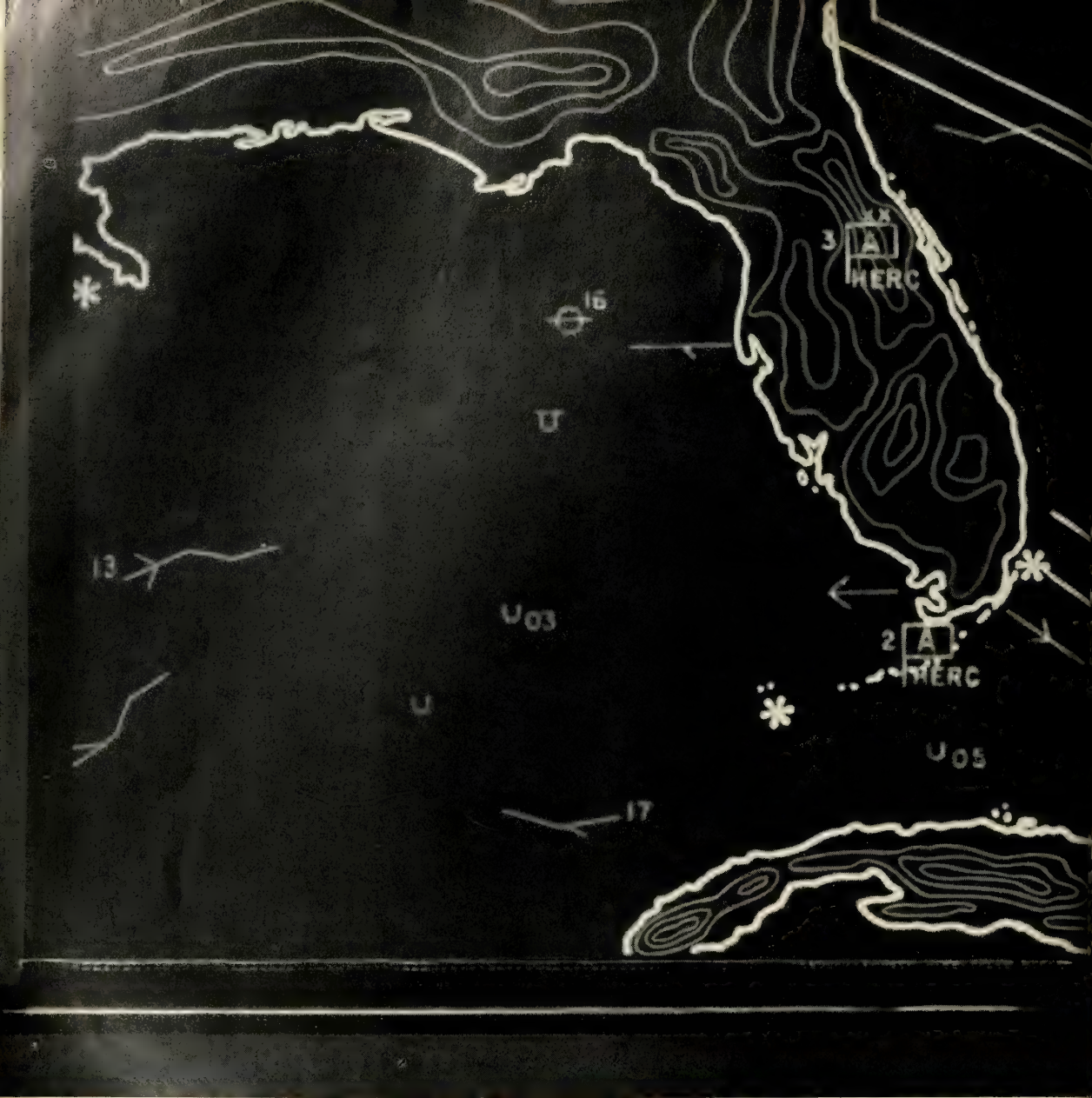
The Ceramics and Graphite Information Center, established at Wright-Patterson AFB, Ohio, needs the help of professional people, universities, industry and other government agencies working in inorganic non-metallic materials.

S. W. Bradstreet, Air Force Materials Lab, told the 1965 Air Force Materials Symposium that R&D devoted to ceramic materials has more than doubled in the past four years. Each month, nearly a thousand papers, articles or talks describe or relate to ceramic materials.

The Center, charged by DOD with interchanging such information within DOD, with contractors, other Federal agencies, their contractors and the general scientific community, is snowed under with work.

Bradstreet says that industry and the professional societies should accelerate their efforts to establish a comprehensive nomenclature consistent with current technology and that universities should provide in their broadened curricula some exposure of the student to informational techniques and to the accurate use of words in titles and abstracts.

The four major problem areas outlined by Bradstreet are: acquisition, critical evaluation, indexing for storage and retrieval and dissemination.



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NORTHROP

AVAILABILITY OF OXIDATION-RESISTANT COATINGS FOR REFRACTORY ALLOYS

SUBSTRATE ALLOY-BASE	CATEGORY (a)	COATING NOMENCLATURE (b)	CURRENT METHODS OF APPLICATION	REPRESENTATIVE DEVELOPER/ SOURCE (C)	PROBABLE TEMPERATURE CAPABILITY, °F, FOR GIVEN LIFETIMES (d)			
					MINUTES (<1 HOUR)	MINUTES ~1 HOUR	MINUTES ~10 HOURS	MINUTES >100 HOURS
Mo	A	Silicide	Pack	Chromally, Vought, Chromizing, Pfaudler	3,200	3,000	2,700	2,500?(e)
			Fluidized Bed	Boeing, Pfaudler	3,200	3,000	2,600	? (f)
	D	Silicide	Slip Pack	Vought	?	2,900	2,600	?
			Slurry	McDonnell	?	3,000?	2,700	?
			Electrophoresis	Vitro	3,200?	3,000?	2,700?	2,600?
	D	W-Si	Vacuum Pack	TRW	3,500?	3,300	3,000?	?
	D	Sn-Al	Slurry	Sylcor	3,300	3,100	2,600	?
Cb	A	Silicide	Pack	Chromizing, Pfaudler, Vought	3,200?	3,000	2,500	?
			Fluidized Bed	Boeing	3,100?	3,000	2,500?	?
	A	Cr-Ti-Si	Vacuum Pack	TRW	3,000	2,900	2,700	2,500
	A	Aluminides	Slurry	McDonnell(LB-2)	3,000	2,600	2,500	?
				North American Aviation	3,100?	3,000?	2,800?	?
				Sylcor	?	?	2,500	2,300
	D	Ag-Si-Al	Slurry	Sylcor	?	3,100	3,000	2,400
	D	Cr-Ti-Si	Slurry-Slip	TRW	?	2,800	2,600	2,400
			(g)Special processing	Sylcor	3,000	2,900	2,600	2,500
			Electrophoresis	Vitro	3,000	2,900	2,700?	2,500?
			Pack, Slurry or Fused Salt	Solar	?	?	2,500?	?
	D	Silicides (Si-Cr, Si-Ti)	Slurry, Slip Pack	McDonnell, Sylcor Vought	?	?	2,600	?
Ta	A	Sn-Al	Slurry	Sylcor	3,400	3,300?	3,000?	2,600?
	D	Ti-W-Si	Pack	Solar	3,100	3,000	2,800	2,500?
	D	Aluminides	Slurry	McDonnell, North American, Sylcor	3,200?	3,000?	2,800?	2,500?
	D	Silicides	Pack	Battelle, Solar, Pfaudler	3,000	2,900	2,700	2,400?
	D	Hf-Ta	Clad (Plasma spray, slurry)	HTRI Marquardt	3,800?	3,500?	>2,500	?
W	A	W-Si	Vacuum Pack	TRW	3,600	3,500	3,400	?
	D	Silicides	Pack	General Telephone	?	3,400	3,300	2,600?

(a) **Categories:** A identifies semi-commercially available coating systems. D refers to coatings uncer current active development.

(b) **Nomenclature:** The terms "Silicide" or "Aluminide" refer to coatings based on compounds formed by diffusion of Si or Al with the substrate metal—e.g., $MoSi_2$ or $CbAl_3$—modified primarily with substrate alloy elements or trace amounts of additives introduced during coating processing.

(c) **Sources:** The lists of representative coating vendors are not meant to be exhaustive, but include only those sources which have released some form of publicity with regard to the type of coating cited.

(d) Temperature capability indicates best estimate of coating lifetime when exposed in air to the temperatures listed. Such estimates include thermal cycling effects, but do not take into account reduced pressure or "pest" problems.

(e) Temperature indications such as 2500? signify either widely variable lifetimes data or very little information available.

(f) ? indicates either no data suitable to provide basis for an estimate or such wide variation as to render any prediction meaningless.

(g) This special processing involves application of Ti or Ti-Cr either by pack or slurry, followed by argon pack siliconizing.

glasses and necessitate development in fiberization methods and equipment suited to temperatures as high as 4,000°F.

There is an intensive effort in the manufacture of metallic fibers—through bundle-drawing techniques. As many as 270 filaments have been drawn in a single bundle.

Whisker-type reinforcements are not yet ideal for structural composites. A great deal of work remains to be done to increase whisker growth rates, to develop selective harvesting procedures and methods for aligning and collimating whiskers into intermediate forms such as yarn or tape, and to develop fabrication procedures for high whisker volume composites.

● **Ablatives**—The Air Force needs ablative materials having a proper balance of ablative, insulative and mechanical properties for hyperenvironmental uses which include temperature ranges from 2,000° to over 20,000°F; surface heating rates from 10 to over 5,000 Btu/ft²-sec; stagnation pressures from 0.01 to more than 100 atmospheres; surface shearing stresses from 1 to plus 600 lb/ft²; chemically reactive atmospheres of air, propellant combustion gases and exposure periods from several seconds to over 30 minutes.

In one of the most comprehensive and detailed presentations at the symposium, D. L. Schmidt of the Materials Lab described areas of Air Force interest in every conceivable type of ablative material and system.

The range of applications cited included the use of ablative elastomers in development of expandable exit cones for very-high-expansion-ratio nozzles. The elastomeric cone is partially folded within the nozzle and the engine firing unfurls and expands the cone in the exhaust stream in a controlled manner.

Schmidt detailed no less than 69 specific areas of research and development in ablative materials technology—any one of them represents a highly sophisticated R&D effort.

● **Structural plastics and adhesives**—Sidney Litvak, T J. Aponyl and R. C. Tomashot described progress in high-temperature polymeric materials from the viewpoint of fundamental breakthrough.

The basic discovery was the use of the chain-forming reaction itself to form stable units in the polymer chain. The representative system described was the formation reaction of the polybenzimidazoles (PBI).

Litvak claimed that improvements in elevated temperature resistance and oxidative stability of reinforced plastic laminates and adhesive bonds must come through improvements in the polymeric base of such materials. This approach is coupled to modifications for the specific end use.

The Materials Lab experts then covered PBI, polymides, polybenzothiazoles and epoxies, pinpointing target areas for current and future research. The adhesives involved are primarily in the same polymer families but include preliminary research into the polybenzoxazoles.

● **Elastomers**—Air Force requirements in elastomers range from aircraft sealants and coating through tires to wire coverings. The rising temperature

regimes now being encountered in planned operational craft pose the toughest problems, but there are others associated with tactical, subsonic weapons systems.

Space problems in elastomeric seals are listed in five general categories. These are basic structure sealing, connectors, cables and static shafts, dynamic shaft seals, exit hatches, internal access doors, docking ports and module deployment seals and seals for large rotating joints.

● **Polymeric coatings**—The problem of corrosion is most evident in polymeric coatings. Only in the last few years has the Air Force officially recognized the need for general aircraft exterior surface painting. In addition, missiles and missile silos need protective coatings in many specialized areas.

The ironical part of coatings research is that as better and better coatings are developed and used, the very materials used to strip such coatings for in-service repairs are eliminated one-by-one. This throws operational commands back to strongly acidic or alkaline materials—which themselves tend to be extremely corrosive.

Coatings from silicone resins currently available can protect at temperatures up to 650°F, but new resins are needed for higher temperatures. While new polymer families are under consideration—the polybenzimidazoles, for instance—many refinements and improvements must be made before these can be applicable in the plus-800°F ranges.

● **Metallic and ceramic materials**—Beryllium interest in the Air Force is extremely high—even though the basic brittleness problem has not yet been solved. Increased usage would result immediately if there were a more complete understanding of the behavior of the current material and if improvements could be made in such things as impact resistance.

Specific answers sought by the Air Force include such points as exactly what would constitute some good fundamental work and whether there are areas now being neglected. Other questions involve the benefits of a fundamental approach to the impact problem and the areas that should be exploited to obtain optimized wrought products.

Since joining remains a problem, what factors should be considered in the development of improved methods in this area? All of these and other questions posed at the symposium reflect a realistic appraisal of the budget limitations existing within the Materials Lab.

Future development and research efforts suggested by AF experts to improve both performance and reliability of high-strength steels include evaluations of plane-strain fracture toughness, resistance to environmental delayed failure and fatigue strengths of ausformed steels.

Others mentioned were:

—Controlling the isothermal embrittlement problem in 18% Ni maraging steels.

—Further evaluation of bainitic microstructures and self-tempering steels.

—Greater understanding of the influence of individual alloying elements.

—Development of alloys with improved relationships of strength-to-toughness and strength-to-delayed failure resistance.

Titanium projects outlined at the symposium included development of a stable creep-resistant Ti-alloy for use up to 1,200°F for extended times. Other problems covered by Paul D. Hendricks in reviewing titanium for AF applications started with reproducibility in commercial alloys.

Hendricks used B120VCA as an example—observation shows a variation in mechanical behavior from heat to heat. Stress corrosion was cited as becoming more important with the use of titanium at elevated temperatures.

Along with the usual trends in developing better alloys and coatings, the Air Force is looking for advanced manufacturing processes to produce specific wrought forms, such as tubing, and foil.

There will be efforts to explore the potential of chromium alloys to better define the extent to which they may be useful in higher temperature ranges. This will include particular emphasis on decreasing the transition temperature and increasing resistance to nitrogen embrittlement.

● **Refractory ceramics**—There is a pressing need for oxidation-resistant materials—capable of maintaining functional integrity in oxygen-bearing environments at temperatures of 3,500° to 4,000°F for hours.

In his review of the situation, John D. Latva described three advances over the past four years. Two were specific materials developments—Carborundum Co.'s Boride-Z and Union Carbide's JTA-Graphite. The third was an increased understanding of the transition metal diborides.

Although JTA is being used in the *Gemini* and *Apollo* systems, little is really known about its true gross high-temperature behavior. The same is true for Boride-Z and will probably hold for the new boride compositions emanating from Materials Lab programs.

Another testing problem is inherent in this area. Latva says a great number and variety of plasma arc simulators are in seemingly constant use—yet there is doubt as to just what these facilities really simulate, and as to whether the data generated are in any way descriptive of materials responses to known environments.

Latva also brought up another point in materials technology. He reported results from a simulated re-entry test of a refractory ceramic in a wind tunnel.

Latva says the results were reported along the following line. "The front face temperature of the specimen exceeded 3,500°F for a 20-minute period of the 60-minute test and there was negligible dimensional change. Additionally, the coating which developed was only a thousandth of an inch thick and the material beneath the coating was unaffected. Though the material outperformed all other materials, the results are inconclusive."

Latva wondered how those concerned with materials development could function when performance does not mean anything to those who must base their recommendations upon it.

● **Metal-ceramic composites**—L. N. Hjelm broused through the entire field of metal-ceramic composites, jumping from problem to problem in this infant technology.

Hjelm joined the chorus bringing up corrosion. He said that although it is difficult to evaluate the stress-corrosion sensitivity of a future landing gear made from a material still in the test-tube stage, there are certain danger signals.

For example, he noted, consideration of beryllium in aluminum or titanium must acknowledge the dissimilar metal corrosion couple that may be built in.

Hjelm also described a basic system for classifying composites in such a way as to aid in the selection of materials for various applications and quickly identify gap areas where critical data is needed. Needless to say, there is, at present, no accepted nomenclature for composite systems. Consequently, information regarding them is poorly indexed and stored and seldom adequately retrieved.

● **Joining processes**—Capt. J. R. Hobbs told the symposium that further improvement of the processes serving the majority of the joining requirements is necessary.

Specific instances included:

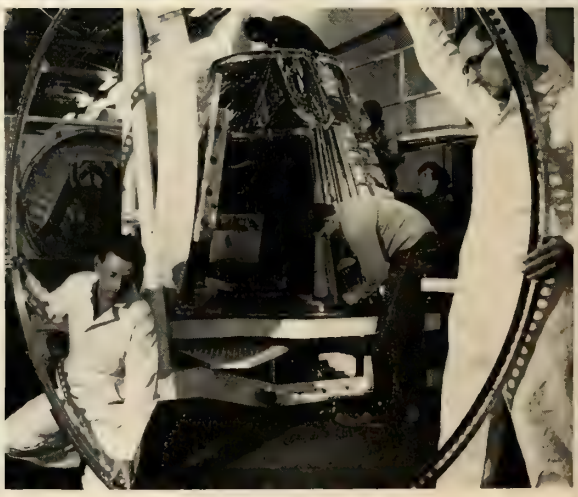
—Improved techniques for thick-section TIG welding, together with improving MIG welding to gain consistently reproducible weld quality with emphasis on lessening the incidence of porosity.

—Electron beam-welding development may be suitable for repairing large welded structures.

—Brazing techniques for joining foil thicknesses of aluminum and titanium are required.

—Plasma arc welding will gain sponsored development.

—Further investigation of laser welding is needed for a thorough process evaluation. ■



Pressurized pilots' cabin is practically all titanium. In addition to the dynamic loads of flight sustained at high ambient temperatures, the cabin must also withstand bending loads of ejection, parachute deployment, landing shock. Furthermore, 75% of the cabin airframe is hatchway. This requires superior structural material and design.

Large forging was machined to form the 94″ diameter heat shield attaching ring located at the base of the pilots' cabin. Cabin structure also features a wide variety of titanium products, including complex forged and machined hinges and brackets, chem-milled sheet, fasteners of all types. Grades: Commercially pure, Ti-6Al-4V, Ti-8Mn.

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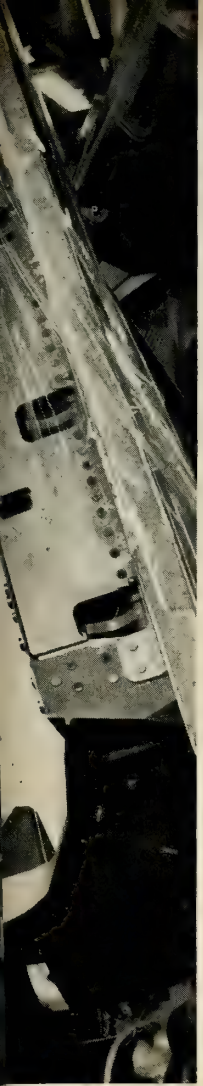

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te-entry control module shows its ancestry in air-raft ring-skin-stringer construction. Closest ring s machined from Ti-6Al-4V forging; ring at other nd, from Ti-7Al-4Mo forging. Maximum depth of inished ring is two inches. This module, not pres-urized, is joined by rivets. Sheet is Ti-5Al-2.5Sn.

Pressure bulkhead is rear wall of the pilots' cabin. Like the rest of the airframe of the cabin module, it consists of double-walled skin of 0.010" commercially pure titanium, inner sheet beaded for added stiffness, welded to ten Ti-5Al-2.5Sn posts to make an airtight pressure vessel.

Titanium pressure vessels are used throughout Gemini spacecraft to hold liquid nitrogen, monomethyl hydrazine, nitrogen tetroxide, and helium. Titanium has been the choice for more than 85% of the pressure vessels that have been built for aircraft and missiles for the past ten years.

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Argentina Paces Latin Space Growth

Nation has launch facility in operation and is planning a second; home-developed rockets tested; UN may play part in cooperation

by William S. Beller

BUENOS AIRES—Argentina is emerging as the leader of space activities in South America—spurred on like many other nations by the fear of not being present when the presumed pot of gold is found at the end of the space rainbow.

Argentina is the only South American country to have launched rockets, to be operating a major launch facility and to be planning a second one. The United Nations may play an active role in this new facility.

The country also is eagerly promoting the Inter-American Committee for Space Research, an unofficial organization that Argentine scientists helped conceive five years ago to encourage Latin American countries to go into space research, particularly with sounding rockets.

The idea is to get the countries to build up their own space resources to where they could eventually be used cooperatively for major joint projects. Brazil, Bolivia and Peru have already set up space commissions as a direct result of the committee's efforts.

Indicative of the type of backing the Committee has is the fact that its president, Teofilo Tabanera, is also president of Argentina's National Committee for Space Research.

● **Scientists kept home**—Argentina also sees immediate benefits from an active space research program. The country will be able to keep some of its trained scientists at home.

This is a problem that has been plaguing Argentina as well as many other Latin American countries. At the University of Buenos Aires, for instance, physical scientists depart for the United States to find work as soon as they are trained.

The financial problem of having these scientists pay their own way through space research is not solved. "Maybe we can get some by-products through the development of the technology and proficiency of our technicians," Tabanera told MISSILES AND ROCKETS. He admitted he didn't think this would happen immediately.

Prestige is an important factor in the drive of individual scientists to get their countries into space research. It figures into the calculations of the countries themselves. Insofar as Latin America is concerned, however, although prestige adds motivation to the mix of other factors, it does not appear to be the dominating motive.

Again, the reason is economic. In Latin America, prestige is a luxury. Only an eventual "payoff" removes space research from this class—but this at the same time puts it into competition for the very limited amount of investment capital Latin American countries have to spend to keep themselves viable. Argentina, for example, has a five-year development plan calling for priority treatment for improvements in transportation, particularly in the merchant marine and aviation, for increased production and development of petrochemicals, for metallurgical work, and for multiplying the generation and distribution of electric power. This is tough competition for space research.

Even when money is budgeted for space work, the inflationary spiral of 25% in Argentina (and higher in Brazil) cuts into the work that can be done. Despite these handicaps, the countries are laying their space plans.

● **Geography stressed**—While the European countries interested in space research are stressing the scientific talent and industrial capabilities within their borders, South American countries are emphasizing their geographic location. In line with a recommendation of the Committee on Space Research (COSPAR), Brazil has built a sounding-rocket station in the vicinity of the magnetic equator. Technicians are presently equipping it to launch rockets carrying meteorological and ionospheric experiments. The first rockets are to be fired before the end of 1965.

Argentina, meanwhile, has signed an agreement with NASA to participate in a synoptic study of the upper atmosphere along a meridian stretching from the Antarctic to Canada. The agreement was signed during the COSPAR meetings at Mar del Plata, Argentina, late last month.

The agreement calls for simultaneous firings of sounding rockets at three different latitudes in Argentina. Scientific information from these firings will

AERIAL VIEW of Chamical base, Argentina: 1) impact zone, 2) launch complex, 3) assembly shop, 4) landing strip, 5) radio station (ionosphere sounder), 6) lodgings.

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be tied in with that obtained from firings in the U.S. and other parts of the world to get a time-oriented picture of the structure of the atmosphere. Plans call for launching about one rocket a day from each site over a short period of time beginning at the end of this year.

The Argentine launches will be made at Chamical range at 30 degrees latitude, Comodoro Rivadaria at 45 degrees latitude, and Matienzo in the Antarctic at 65 degrees latitude. The U.S. will furnish some of the sounding rockets, which will include five Rocket Power, Inc., *Boosted Dart* vehicles, and will lend some equipment, which will include a launcher and radar.

Argentina will buy 10 Atlantic Research *Arcas* rockets, 16 *Boosted Darts,* and payloads, which will include sodium apparatus for vapor release to measure the upper-atmospheric winds. In line with NASA policy, there will be no exchange of money between the two countries. Argentina will contribute the efforts of its scientists and the use of its facilities, while NASA will pay in the U.S. for what it furnishes to Argentina.

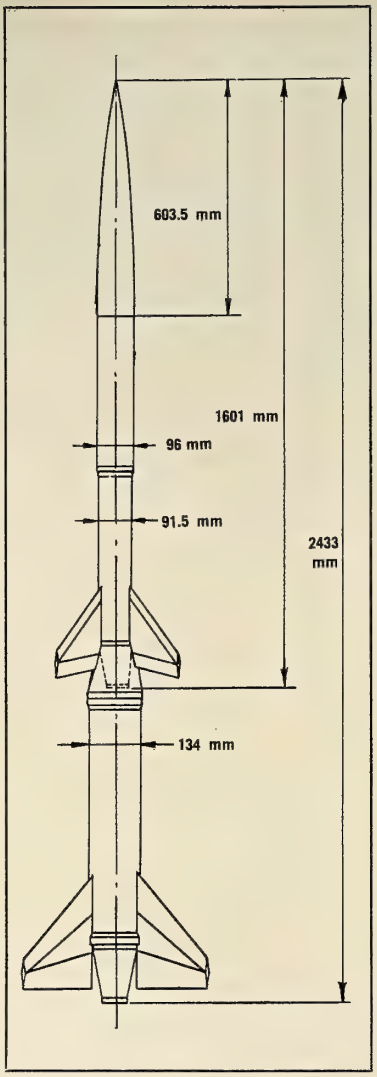
● **Argentine facilities**—With nearly three years of rocket-launching experience, Argentina is ready to take another step forward in space research. It is planning to build a second major launching site, one not as limited by populated areas as Chamical.

Chamical is located in the western part of Argentina, 250 km from Cordoba. Although it is in an isolated area on large salt flats, not far from a mountain range, the security zone is only 150 km from the launching point. This limits the maximum safe altitude for rockets to about 250 km.

Since late 1962, when the base went into operation, "we have fired two *Nike-Cajuns* for ionospheric experiments made in cooperation with NASA, 11 *Centaures* in cooperation with the French space agency (CNES), and 40 small Argentine rockets for development test purposes," said Tabenera.

The Argentine rockets, known as *Gamma-Centauros* but having no relation to the French *Centaures,* were made at the Air Ministry's factory known as Dinfia, located at Cordoba. It is reported that the government has outfitted Dinfia with over $100 million worth of equipment and machinery over the past 20 years. Since the facility is not being used at anywhere near capacity, there presumably is room to build much larger and more sophisticated space hardware than small rockets, as well as military and civilian aircraft. Negotiations are said to be taking place between Argentine officials and U.S. concerns interested in aircraft manufacture or conversions at Dinfia.

The *Gamma-Centauro* is a two-stage, solid rocket, able to take a five-kg payload to an altitude of between 20 and 30 km. It weighs 31.5 kg at launch. This rocket is expected to play a large role in the country's cosmic ray research.



ARGENTINA'S Gamma-Centauro rocket.

At the same time, Dinfia is developing *Orion,* a one-stage solid rocket, which was static-tested successfully late last month. *Orion* is designed to reach 80 km with a five-kg payload. Both rockets are developments of the Argentine Air Ministry.

● **Mar del Plata site**—Argentina's new launching site will be on the Atlantic Ocean, near Mar del Plata. This will provide an almost unlimited range to the east and south, and, to the northeast, a longer range than that of Cape Kennedy. Tabanera foresees eventual launching of satellites from this site.

"We hope by the middle of next year to fire the French *Dragon* (sounding rocket) to an altitude of 500 km from this new facility," said Tabanera. He added that his country is thinking about putting the new base, or possibly Chamical, under the sponsorship of the United Nations.

If this were done, the launching sites would be open to any nations in the UN. Costs of operations would be shared between the host country and the visitors, and the results of experiments would be available to the scientific community through publication in international journals.

The advantage to the host country is that through cooperative efforts it could get economic aid for space research it possibly could not afford on its own, and could get technical and scientific advice that otherwise would be difficult to obtain.

● **The UN in space**—UN interest in promoting space research through international launch sites is relatively new. It started with a set of general principles laid down in 1962 by the UN Committee on the Peaceful Uses of Outer Space. As a result, the Thumba Equatorial Rocket Launching Site (TERLS) in India was put under UN sponsorship last year.

Through its work, the UN may find itself a rallying place for all underdeveloped countries with an interest in space. The Outer Space Committee has already called for UN assistance to increase the value of TERLS as a training center for Indian as well as other scientists.

"In this connection," A. H. Abdel-Ghani, chief of the Outer Space Group, told a COSPAR audience at Mar del Plata, "other countries (besides India) have indicated the possibility of requesting the United Nations' sponsorship for similar ranges, which would serve as international sites available for scientists from all over the world for research and training in the space field."

These urgings to the UN to take a more active part in space are resulting in expansion of its activities.

A UN interagency group recently noted "the growing interest, particularly in the smaller countries, in the development of a training program under the auspices of the Outer Space Committee, which has hitherto concerned itself primarily with the compilation of information and the organization of clearing-house arrangements."

It is difficult at this time to tell how far Latin America can go into space research. If it uses the efforts of individual countries working alone, the work will probably remain at a low level. Cooperatively, the work can become more significant. If the UN takes a strong role, then perhaps an *entente* can be formed, which will make important contributions to space research. ■

Effects of Cabin Atmosphere and Spacecraft Accelerations To Be Studied

by Heather M. David

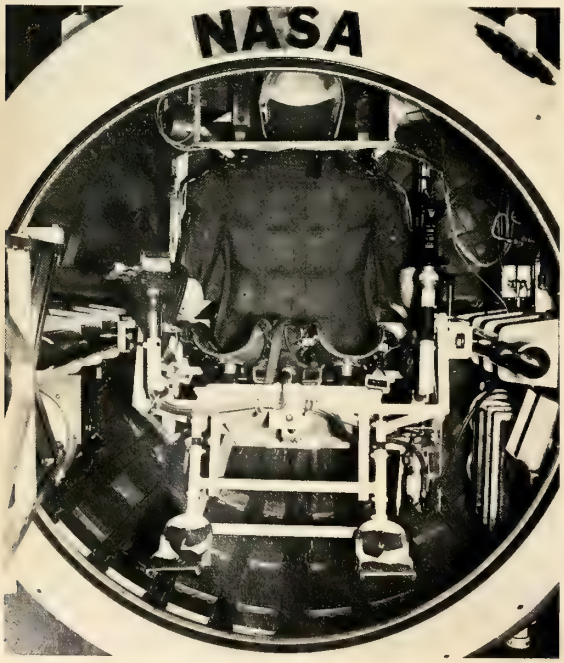
A STUDY THAT will attempt to provide a hard answer to what effects various atmospheres coupled with spacecraft accelerations will have on astronauts' lungs will begin this month at the Garrett Corp. in Los Angeles.

According to Garrett medical director Dr. James Waggoner, tests of three different atmospheres—pure oxygen at two different pressure levels, and a mixture of oxygen and nitrogen—will comprise the initial series of experiments. These will be accomplished in approximately five weeks.

Some consideration is being given to follow-on studies with helium, an atmospheric diluent that is gaining favor with spacecraft designers and physiologists. Two of the *Manned Orbiting Laboratory* study companies—Douglas and Lockheed—favor a helium/oxygen atmosphere, while the other two, Boeing and General Electric, lean to nitrogen/oxygen. (M/R, May 3, p. 15).

● **Evidence of problem**—First evidence that some lung damage might occur after breathing oxygen-rich atmospheres was reported several years ago by the Royal Air Force. Physicians checking out pilots returning after strenuous missions noticed that pilots often coughed or had hoarse voices during their physical examinations and sometimes for some hours afterward. After the RAF incorporated X-rays as a routine feature of these examinations, they discovered that there were signs of collapse of small lung sacs. This damage lasted anywhere from one breath to 48 hours, Waggoner related.

The exact mechanism that causes this damage is not fully understood, and there is no bank of data that tells exactly when the damage may occur, or under what conditions and g forces. For this reason, NASA's Ames Research Center has contracted with Garrett for the studies.



GARRETT CORP.'S pulmonary pathology capsule, in which subjects can be kept in simulated spacecraft atmospheres while riding the UCLA centrifuge.

Four subjects, all of whom have passed the astronaut physicals and three of whom are pilots, will pre-breathe the chosen atmosphere, then be subjected to a force of 6 g's for two minutes on the centrifuge at the University of California. This amount, Waggoner said, should be enough to produce any changes, if they are going to occur with that atmosphere. First tests will be made with the subjects receiving the forces chest to back, but the same tests may be run later in the "eyeballs out" position. There is some evidence, Waggoner said, that eyeballs out could have its own advantages to the well-being of the subjects once they become used to it.

● **Test method**—The subjects will be placed, in individual turn, in the pulmonary pathology capsule (see photo) designed and built by Garrett's AiResearch Manufacturing Division.

The first atmosphere to be tested will be 100% oxygen at 3.5 psi. Each subject will pre-breathe this atmosphere for three hours, then be placed in the capsule on a centrifuge at the University of California, Los Angeles. Immediately after the acceleration period, the subjects will be lifted out of the centrifuge area on a rail system, ensuring that they do not move their bodies in any manner.

Complete physicals will be given, including X-rays, which will give wet readings on the spot to note changes immediately. Each subject will be given a rest period of from 7 to 10 days before the next test, or until any damage that might have occurred disappears.

Second test for each subject will be at the same 100% oxygen atmosphere, but with a pre-breathing period of 8 hours. This will help determine the exact extent to which the atmosphere affects the situation.

Middle series of tests will occur with 100% oxygen at 7.35 psi—first with three hours, then eight hours pre-breathing. Although this atmosphere is not being considered for spacecraft, it will help determine what part pressure plays. The same routine is planned with the two pre-breathing periods with oxygen/nitrogen, about 50/50, at 7.35 psi. ■

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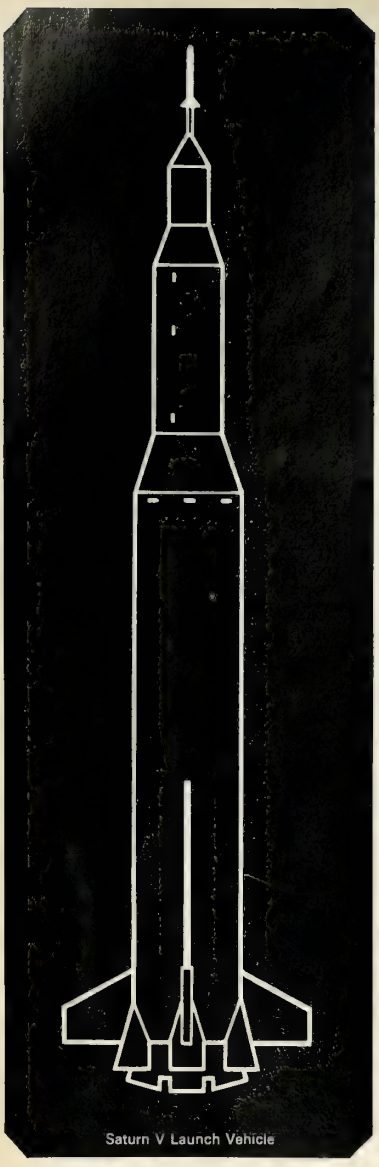
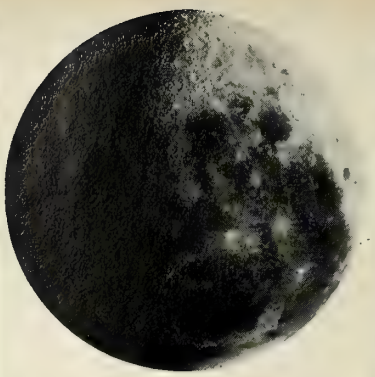
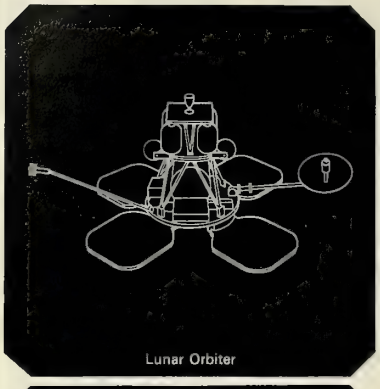
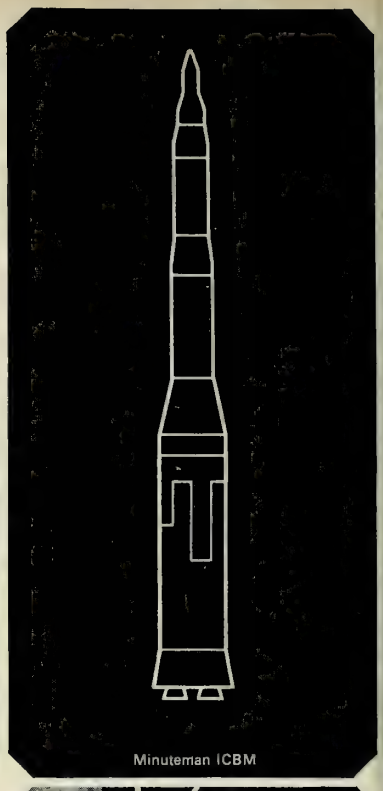


Saturn V Launch Vehicle



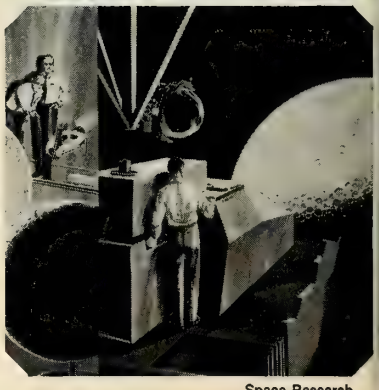


Lunar Orbiter



Minuteman ICBM

Space-Age Boeing Openings



Space Research

for Engineers and Scientists

The Boeing Company's Aero-Space Division, major contractor for the Saturn V launch vehicle, Minuteman ICBM and the Lunar Orbiter, has a number of challenging opportunities for graduate engineers and scientists. (See list in right-hand column.) Assignments, which vary with each Boeing facility, are at Cape Kennedy, Fla.; Huntsville, Ala.; New Orleans, La.; Seattle, Wash., and Vandenberg AFB, Calif.

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300-in.-dia. Liquid 'Orbiting Eye' Proposed

by Rex Pay

LOS ANGELES—A ten-ton "Orbiting Eye" containing a 300-in.-dia. liquid telescope could extend "by orders of magnitude man's optical reach into the universe," says John H. Bloomer, a space optics consultant.

Speaking at the Aerospace Electronics Symposium sponsored by the Aerospace Electrical Society and the American Astronautical Society, Bloomer outlined a proposed telescope that would make use of a liquid-gallium mirror and a liquid-silicone plastic corrector lens to obtain a theoretical resolution of 0.02 arc seconds and a 10° field of view.

He suggested this would be more than sufficient to give detailed information about lunar and planetary topographies. Also, three such satellites in synchronous orbit could provide "constant surveillance of every inch of the Earth's aerospace," he said, enabling detection and tracking of ICBM's emerging from the tropopause.

Images probably would be transmitted from the 50-ft.-dia. spherical satellite by means of a bank of vidicons and a microwave link.

Power for the on-board electronics would come from flexible solar cells covering the exterior of the satellite.

● **Lens and mirror**—The main mirror is a liquid-gallium film about 1 in. thick. About the same thickness of Dow-Corning DC-200 silicone oil film is used for the corrector. When the satellite is in synchronous orbit, the free surfaces of these films are nearly spherical. A tubular structure with an internal diameter of 300 in. would hold the main optical elements which form a Maksutov-Bouwers system.

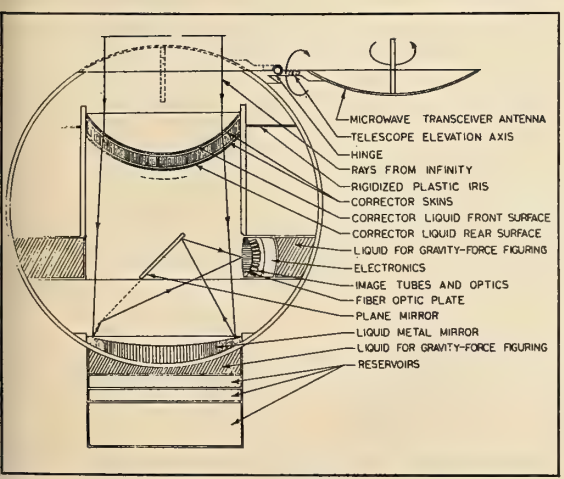
Liquid gallium is silver-white and has a reflectivity of 90% in the 4-8,100 Angstrom region. The melting point is 85.55°F and the boiling point 3,601°F.

DC-200 has a transmission approaching 100% in the visible band and in the near infrared. In ultra-high vacuum, its volatility becomes immeasurably low.

Primary control of lens and mirror curvature thickness and separation would be achieved by adding or subtracting liquid from the mirror or corrector liquid masses. Bloomer said fine control can be obtained by ballast mass adjustments to give the optics any desired figure correct to 0.05 wavelength over the entire surface.

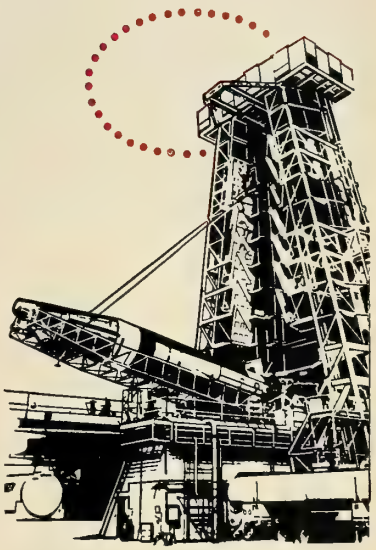
The corrector lens makes use of clear silicone plastic skins joined by silicone plastic threads (as in the Goodyear "Airmat" principle) and pressurized by silicone oil. The surfaces of the corrector are liquid films that adhere to the two outer surfaces of the skins. These form a Maksutov meniscus lens that corrects spherical aberration.

The Orbiting Eye would be injected into space in a folded configuration. Gas pressure would then expand aluminum honeycomb bounded by rigidized heavy Mylar skins to form the main spherical shell of the satellite. The support tube for the optical elements would contain a dense plastic foam interior. ■



BY USE OF liquid lens and mirror surfaces the F/1 Orbiting Eye avoids structural, grinding and polishing problems met in conventional telescopes and thus makes feasible extremely large diameters.

Coating problems on launcher arms, launchers, flame deflectors, flame buckets



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To lead and perform studies of electrical systems associated with advanced nuclear power systems for spacecraft auxiliary power and propulsion. Included here is the definition of systems requirements, determination of system characteristics, performance optimizations, and evaluation of the state-of-the-art in the areas of power conditioning equipment (static switching circuits, transformer design, etc.), alternators, E-M pump technology, control systems, electrical power transmission, and electronic payload equipment. A broad range of experience in electrical power systems and analog simulation is desired, with proven analytical ability, and skill in communicating (written and oral presentations).

LUBRICATION SPECIALIST

Chemical Engineer, Ph.D. or equivalent, with experience in lubrication, friction, and wear and an interest in solving practical lubrication problems encountered in airborne components. Understanding of spacecraft lubrication problems desirable but not mandatory.

GUIDANCE AND CONTROL SYSTEMS ENGINEERS

Conceive and conduct analytical studies resulting in the design and development of sophisticated systems for the navigation, guidance and control of Space Vehicles. Both active and passive techniques are currently under study and development for the control of Orbiting Spacecraft, rendezvous techniques, interplanetary flight and specialized military systems. Requires BSEE, ME or Physics. Intermediate and senior positions.

ENGINEERS — THERMODYNAMICS

Responsible for the design adequacy of orbital and re-entry space vehicles with respect to thermodynamics, heat transfer and aerodynamic heating factors. Will engage in synthesis and parametric studies pertaining to configuration heat protection system performances and internal cooling system performance. Requires MSME, AE or Chemical Engineering with 2 to 6 years' aerospace experience.

ENGINEERS — ORBIT DYNAMICS

Engage in earth orbit analysis, orbit determination, orbit prediction, statistical error analysis and interplanetary trajectory selection. Requires BSAE or ME with experience in celestial mechanics, orbit perturbation theory and Navigation and Guidance theory.

ENGINEERS — STRUCTURES

Perform structural loads and stress analysis on space vehicles and associated components. Support hardware design efforts, study programs and proposals. Requires minimum BS in Engineering with at least 4 years of applicable experience.

OPERATIONS ANALYSIS ENGINEERS

3 to 10 years' experience in space vehicle systems design, development, test and operations. Emphasis on hardware knowledge, systems integration and data analysis. Must be interested in responsible assignment and customer contact. Assignment is in technical support of military space programs.

PROJECT ENGINEERS

Responsible for technical direction of all work on assigned programs. This includes interpreting customer requirements, technical integration, establishing program direction and funding, and measurement of progress. Requires engineering degree, strong administrative capability and a thorough knowledge of engineering, manufacturing and quality control.

PhD — CONTINUUM MECHANICS

Theoretical studies of shock waves in solids, plastic wave propagation, and dynamic deformation and fracture of structures. Theoretical studies of the internal mechanics of composite materials including the effects of constituent geometry, inelastic and anisotropic constituents and thermal effects. Experimental and theoretical studies of constitutive relations and failure mechanisms for slow and very high strain rate effects in homogeneous, composite and layered materials and structures. Utilization of modern numerical methods for research in continuum mechanics.

ENGINEERS — COMMAND & TELEMETRY DESIGN

Responsible for the design of new spacecraft components from conceptual phase through detailed design, production, test and use. Includes airborne and ground telemetry, voice and video circuitry and sensor components. Requires comprehension of analog and digital circuitry, receiver and transmitter design experience and a knowledge of microelectronics. BS/MSEE or Physics with minimum of 4 years experience.

ENGINEERS — MILITARY SYSTEMS

Plan, direct and contribute to studies of advanced Military Space Systems by means of synthesis and design principles leading to the establishment of satellite vehicle system definition. Emphasis is placed on working systems knowledge in the field of Spacecraft Communications, Guidance and Control and Information Systems. Individuals will contribute to preproposal, proposal and contract studies. Requires MS in Systems Engineering, Physics or EE and minimum of 7 years applicable experience.

SYSTEMS ANALYSIS ENGINEERS

Interpret satellite systems design and operational mission requirements. Identify and analyze performance parameters and assess their influence on the vehicle system. Perform design trade-off analyses and prescribe acceptable systems behavior, operating domains, tolerances and performance variations. Develop the analytical facility to implement systems synthesis and optimization and evaluate development progress, malfunction, reliability, effectiveness, vulnerability and capability of the vehicle systems. Requires BS/MS EE, ME or Physics and broad understanding of missile/spacecraft subsystems.

ELECTRICAL SUBSYSTEMS ENGINEERS

Responsible for the design, development testing and qualification of the assigned Spacecraft Electrical Subsystem, including all components. Emphasis is on airborne control for the electrical distribution in a space vehicle, including electrical power and signal distribution for AGE. Requires BSEE with minimum of 4 years' applicable experience.

INFRARED AND OPTICS SPECIALIST

Responsible for originating, integrating and presenting technical studies of a systems analysis nature. Plan and direct experimental programs to validate new systems and subsystems concepts. Interpret the tactical and strategic technical requirements of the customer in the IR/Optical area and translate these into relationships that can be used for synthesis of AICBM systems. Requires MS/PhD in Physics and broad systems experience in IR and/or optics instrumentation.

RELIABILITY ENGINEERS

Individuals will be responsible for determining reliability requirements on assigned programs, to include: design, reliability; failure mode and effects; system and component analysis; test design and evaluation; failure analysis; maintainability; risk assessment; cost analysis and vendor reliability. Requires BSEE or Physics and 3 to 5 years' applicable experience.

PRODUCIBILITY ENGINEERS

Work directly with design engineering to establish manufacturing feasibility of structural, electrical, and electronic design concepts. Will act as manufacturing engineering liaison man to design engineering in the resolution of problems in the production area. Requires ME or EE with 6 to 8 years' combined engineering and manufacturing experience.

NUCLEAR SYSTEMS ENGINEERS

To perform analytical studies of advanced nuclear spacecraft, with emphasis on power plant-vehicle integration problems, system "trade-off" analyses and optimization, analysis of low-thrust propulsion requirements and trajectories. An MS degree in mechanical or aero engineering is preferable. Experience need not be in nuclear area, but the incumbent should possess broad capabilities for systems analysis work and be familiar with the use of large scale computers. A recent MS graduate would be considered for this position. The incumbent will work directly with an experienced project engineer and would learn the various nuclear spacecraft technologies "on the job."

PhD — FIBER-REINFORCED PLASTICS

PhD, or equivalent experience, for experimental research in reinforced composites. Should have familiarity with organic polymers, some knowledge of surface chemistry and physics and mathematical background sufficient to handle stress analyses.

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Mergers and Acquisitions

Teledyne, Inc., Hawthorn, Calif., has reached agreement in principle to acquire Geotechnical Corp. of Garland, Tex. Geotechnical, which performs research and makes instruments for use in the earth sciences, will be operated as a division of Teledyne without any change in management or personnel. The proposal is subject to final approval of both companies, shareholders of Geotechnical and the California Corporation Commissioner. The purchase would be based on an exchange of stock involving three shares of Geotechnical for one share of Teledyne. . . . *Milgo Electronic Corp., Miami, Fla., has acquired Control Technology, Inc., of Long Beach, Calif. CTI, which will be operated as a wholly owned subsidiary of Milgo, will supply Milgo with software, training and applications support in the fields of analog and hybrid computation. Milgo is engaged in research and development and also builds a wide range of data handling and commercial electronic equipment items.* . . . Microdot, Inc., Pasadena, Calif., has acquired Lincoln Dynamics, Inc., of Los Angeles. Lincoln becomes a wholly owned subsidiary of Microdot, and its name will be changed to Microdot Magentics, Inc. Property and personnel of Lincoln Dynamics have been merged with the Magnetics Div. of Microdot. . . . *Raytheon Co., Lexington, Mass., has announced plans to acquire Edex Corp. of Mountain View, Calif., as its second acquisition in the education field within a week (M/R, June 7, p. 47). To be included in the Edex acquisition will be Drivex Corp., a recently formed Edex subsidiary that manufactures auto driver trainer simulators. Edex develops and manufactures coordinated teaching systems for schools, industry and government.* . . . Lear Siegler, Inc., Santa Monica, Calif., has acquired all assets of Hypro Engineering, Inc., of Minneapolis, Minn. The action was formally approved earlier this year by the boards of directors of both companies.

New Activities

TRW Space Technology Laboratories is changing its name to TRW Systems Group, effective July 1. The change is to emphasize the group's expanded role in non-space programs. . . . *Ikor, Inc., has been formed in Waltham, Mass., to engage in design, development and production in the areas of geophysical measurements, instrumentation and control systems, cryogenic measurements and special purpose computer systems.* . . . Texscan Corp. has been formed in Indianapolis, Ind., to specialize in the design and manufacture of RF sweep instrumentation and associated products for commercial and military customers. . . . *Martin Marietta Corp. and United States Rubber Co. have formed Isochem, Inc., to operate the chemical processing plant and develop a commercial fission products operation at the Atomic Energy Commission's Hanford, Wash., facility. The company is jointly owned, with Martin Marietta and U.S. Rubber each having a 50% interest.* . . . Federal-Mogul-Bower Bearings, Inc., Detroit, has changed its name to Federal-Mogul Corp. to reflect its expanded interests beyond just the manufacture of bearings. The firm now makes other products ranging from powdered metal parts to space suits. . . . *International Resistance Co., Philadelphia, has established a Consumer and Distributor Products Div. to market products including products of other firms, through consumer and electronics distributor outlets.*

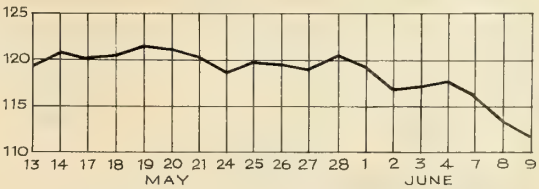
Electronic Space Structures Corp., West Concord, Mass., has formed a subsidiary, Communications Structures, Inc., to specialize in the design, development, manufacture and installation of antennas and associated microwave hardware.

Facility Expansions

Final calibration tests are being conducted at Lockheed-California's Mach 35 hypervelocity shock tunnel at Burbank, Calif. The tunnel, to be used in testing 10,000-mph aircraft and spacecraft, has a maximum diameter of 9 ft. and operates by driving a high-temperature, high-pressure volume of helium or hydrogen through a shaft, compressing the gas and driving it through a nozzle into the test area. . . . *Rocketdyne Div. of North American Aviation has completed the fourth building in a complex of manufacturing and administrative facilities at Warner Ranch in the San Franando Valley of California. The $2-million building will contain 176,000 sq. ft. of office, manufacturing, laboratory and services space.* . . . Burr-Brown Research Corp. has moved to Tucson, Ariz., International Airport.

Missile/Space Stock Index

The highly successful *Gemini 4* flight had no discernible effect on the stock market. Missile/space stocks followed the market's general downward plunge, which resulted in part from statements by Federal Reserve Board Chairman William McChesney Martin that similarities to the situation in the 1920's are appearing in the economy. Profit takers reportedly are hitting those stocks that have had large growth recently, including defense and aerospace issues.



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
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STRUCTURES AND DYNAMIC TEST ENGINEERS FOR ADVANCED MISSILES AND SPACECRAFT

Unusually interesting positions exist for qualified engineers who can perform on a variety of high interest aerospace vehicle studies and who have a capability for proposal preparation.

Responsibilities for the area will include: Preparation of preliminary concepts, structural and component installation designs for proposals and advanced studies in missiles and spacecraft programs; performance of weight, balance and inertia studies; providing written proposal materials.

Experience in aircraft or missile structural design is essential, with a working knowledge of preliminary stress analysis, effects of extreme environment, and applicable materials. Applicants should be generally familiar with various vehicle subsystems, particularly in the propulsion and attitude control areas.

Qualifications should include a B.S. degree from an accredited university with 5 to 10 years applicable experience.

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AIR FORCE

$10,789,100—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for continued launch services in the *Agena-D* program.

$2,837,000—**Aerojet-General Corp.,** Sacramento, Calif., for work on *Titan III*.

$2,500,000—**Philco Corp.,** Palo Alto, Calif., for work on a satellite control network.

$2,200,000—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., as part of the CRESS program.

$2,100,000—**General Electric Co.,** New York City, first segment of a $6 million contract to manufacture optical sights for *Phantom II* aircraft.

$1,663,000—**International Telephone and Telegraph Corp.,** Paramus, N.J., for continued work on defense early warning system.

$1,530,730—**Wilcox Electric Co.,** Kansas City, Mo., for communications equipment.

$1,233,047—**General Dynamics Corp.,** San Diego, Calif., for production of spare parts for the *Atlas-Agena* booster.

$700,000—**General Precision, Inc.,** Link Group, Binghampton, N.Y., for a film data readout system.

ARMY

$10,917,962—**Hercules Powder Co.,** Wilmington, Del., for loading and packing explosives and *Nike* boosters.

$631,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., for a classified program.

$310,000—**American Electronics Laboratory, Inc.,** Colmar, Pa., for three exploratory development models of the vehicular communications jammer.

$153,140—**General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., Woburn, Mass., for study to increase the reliability of several types of microwave diodes.

$120,000—**Sperry Rand Corp.,** Sperry Gyroscope Co., Great Neck, N.Y., for 18 months extension of research study of continuous wave side-looking airborne radar.

$109,228—**Hughes Aircraft Co.,** Component Div., Fullerton, Calif., for research work for 15 months on radiation effects of microelectronic circuits.

$99,033—**Hughes Aircraft Co.,** Aerospace Group, Aeronautical Systems Div., Culver City, Calif., for a 12-month systems study on short-range guided missiles, surface-to-surface and surface-to-air.

$94,326—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., for interference reduction techniques for receivers.

$75,000—**Kaysam Corp. of America,** Paterson, N.J., for research work leading to the development of exploratory models of a fast radar reflective balloon.

$69,854—**United Aircraft Corp.,** Hamilton Standard Div., Broad Brook, Conn., for 12 months research and development work on techniques for production of reliable microbands for hybrid microcircuits.

$49,300—**Philco Corp.,** Western Development Laboratories, Palo Alto, Calif., for continued investigation of feasibility of universal link terminal for use in active and passive communications satellites.

$44,234—**Health Research, Inc.,** Buffalo, N.Y., for continuation of studies on effects of laser radiation on biological systems.

NAVY

$26,272,074—**Bendix Corp.,** Mishawaka Div., Mishawaka, Ind., for manufacture, assembly and checkout of *Talos* guidance control and airframe group.

$3,179,975—**Motorola, Inc.,** Scottsdale, Ariz., for work on guidance and control systems for *Sidewinder* air-to-air missiles.

$1,416,114—**Bendix Corp.,** Detroit, for work on unspecified navigation and communications system.

$1,314,264—**Planning Research Corp.,** Los Angeles, for additional study in the development of intelligence data processing.

$206,016—**Clevite Corp.,** Ordnance Div., Cleveland, Ohio, for design, fabrication and test of a novel guidance system for torpedoes, including transducer, signal processing and control components.

$200,000—**Korad Corp.,** Santa Monica, Calif., for research and development studies for *Poseidon* guidance and fire control capability.

$200,000—**General Electric Co.,** Pittsfield, Mass., for research and development studies for *Poseidon* guidance and fire control capability.

$90,000—**Korad Corp.,** Santa Monica, Calif., for *Polaris* guidance and fire control research and development.

$90,000—**General Electric Co.,** Pittsfield, Mass., for *Polaris* guidance and fire control research and development effort.

North American Aviation, Inc., Autonetics Div., Anaheim, Calif., for 11-month sonar signal analysis study (amount not disclosed).

AIR FORCE and NAVY

$1,655,000—**John Fluke Manufacturing Co., Inc.,** Seattle, Wash., for manufacture of precision electronic measuring instruments and components.

ADVANCED RESEARCH PROJECTS AGENCY

$2,500,000—**Union Carbide Corp.,** Carbon Products Div., New York City, **Case Institute of Technology,** Cleveland, Ohio, and **Textron, Inc.,** Bell Aerosystems Co., Buffalo, N.Y., for a research program on carbon and graphite composite materials.

NASA

$123,498—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., for a 14-month study on advanced analytical techniques to describe the physical and chemical phenomena occurring when a manned spacecraft re-enters the Earth's atmosphere.

$64,000—**Space General Corp.,** El Monte, Calif., for small rocket payload recovery system.

$58,225—**Fairchild Hiller Corp.,** Bladensburg, Md., for study of the analysis of *Pegasus* flight data.

$39,875—**Aracon Geophysics Corp.,** Newton, Mass., for an evaluation of the meteorological content and application of *Nimbus I* data.

$38,244—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for laser system for use in diagnostic studies of plasma.

$35,300—**Technical Appliance Corp.,** Sherburne, N.Y., for hydraulically driven telemetry array.

INDUSTRY

$1,155,000—**The Electrada Corp.,** Culver City, Calif., from **Grumman Aircraft Engineering Co.,** Bethpage, N.Y., for the manufacture of titanium helium storage vessels in connection with *Apollo* lunar expeditions.

$500,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., from the **Boeing Co.,** Seattle, for classified programs.

$162,136—**Raymond Engineering Laboratory, Inc.,** Middletown, Conn., from **Harry Diamond Laboratories,** Washington, D.C., for arming and safing device.

$98,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., from **Collins Radio Co.,** Dallas, for work connected with the *Apollo* program.

$82,000—**Snap-Tite, Inc.,** Pittsburgh, Pa., from **United Aircraft Corp.,** Hamilton Standard Div., Windsor Locks, Conn., to provide quick-disconnect couplings for the *Saturn V* program.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

U.S. Army Missile Command
Redstone Arsenal, Alabama

Research and development services in connection with the analysis of multiple application criteria laser semi-active missile system. RFP restricted to Northrop Corp., Nortronics Div., Anaheim, Calif., on the basis of research capabilities. Firms interested in subcontracting opportunities should contact the above mentioned firm.

U.S. Army Missile Command
Redstone Arsenal, Alabama

Contract under negotiation with Martin Co.'s Research Institute for Advanced Studies, Baltimore, for research studies for development of a stabilizer for an oxidizer used in rocket propellant. Firms interested in subcontracting opportunities should contact the above mentioned firm.

Chief, Bureau of Ships
Department of Navy
Washington, D.C. 20360

RFP being issued to Tracor, Inc., Austin, Tex., for a study to determine influence of oceanographic factors on sonar echo coherence. Firms interested in subcontracting opportunities should contact the above mentioned firm.

Chief, Bureau of Ships
Department of Navy
Washington, D.C. 20360

RFP being issued to Booz-Allen Applied Research, Inc., Chicago, for continuation of evaluation, planning and project evaluation services relating to the *Seahawk* program. Work accomplished to date is a prerequisite to performance of this work. Firms interested in subcontracting opoprtunities should contact the above mentioned firm.

Chief, Bureau of Ships
Department of Navy
Washington, D.C. 20360

RFP is being sent to Tracor, Inc., Austin, Tex., for an analysis of space/time signal processing theory and techniques in support of ASW Systems Project Office program. Study relates to associated studies being taken by Tracor. Firms interested in subcontracting opportunities should contact the above mentioned firm.

Procurement Division
Building 4603
Aberdeen Proving Ground, Maryland

Negotiations are being conducted with Southwest Research Institute, San Antonio, Tex., for a feasibility study in new testing techniques for blast sphere facility. RFP RD-200-65 not available; for information only.

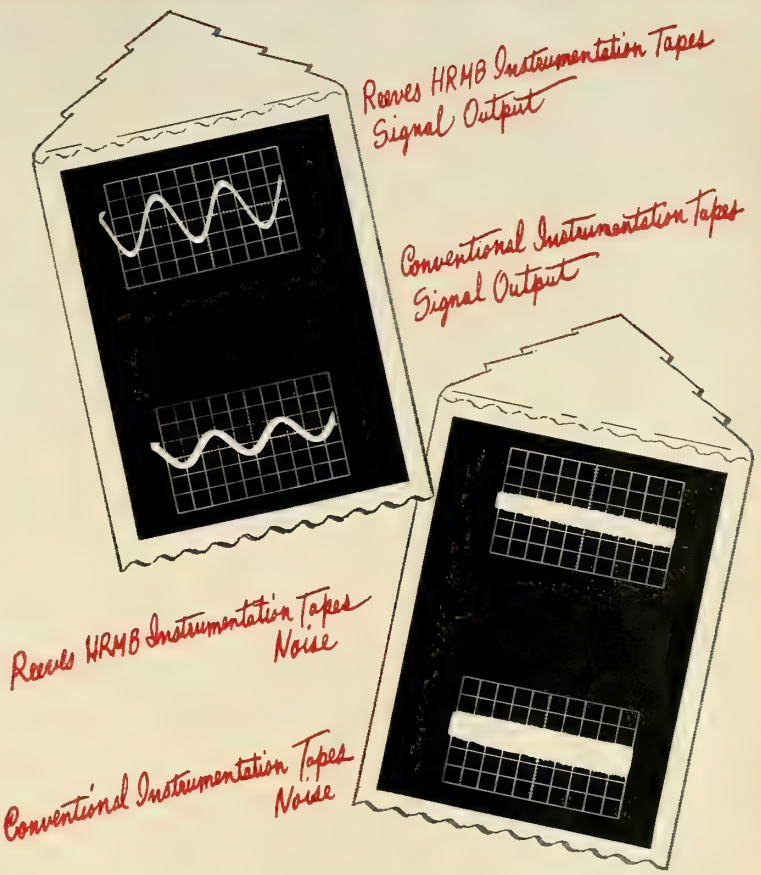
National Aeronautics and Space Administration
Ames Research Center
Moffett Field, California 94035

Negotiations being conducted with General Electric Co., Cincinnati, Ohio, for a study of lift-fan technology and research hardware. For information only; RFP not available.

Bureau of Naval Weapons
Washington, D.C. 20360

Bureau will solicit a quotation from Howard Research Corp., Arlington, Va., for engineering support for advanced control systems for the deep-submergence vehicle. RFP not available; for information only.

SEE WHY THE NEW REEVES INSTRUMENTATION TAPES ARE THE ONLY TAPES YOU CAN AFFORD TO USE?



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In addition to its better signal output and noise characteristics, Type HRMB offers these improvements over conventional instrumentation tapes:

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*Reeves Soundcraft T.M.

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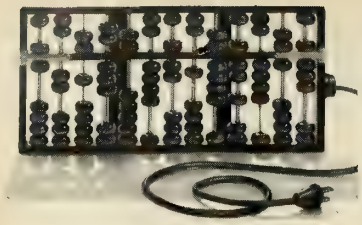

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Lockheed Missiles and Space Company operates the largest single industrial digital computer facility in the United States. It provides exceptionally versatile and advanced computation and data reduction services to all parts of the Company.

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DEVELOP advanced software operating and programming systems on IBM 1410/7094 computers and Univac 1107/1108 computers.

OPTIMIZE commercial programs for efficiency and cost reduction and adapt programs to new equipment, certifying for conformance.

DEVELOP real-time data systems for commercial applications such as source data acquisition, updating, retrieval and administrative control systems.

ANALYZE and program new business applications on medium and large scale computers. Develop financial, engineering, manufacturing and procurement integrated systems for real-time and off-line functions.

PROGRAM and operate analog or hybrid computers and differential analyzers. Define models for simulation of aerospace guidance and control problems and analyze results.

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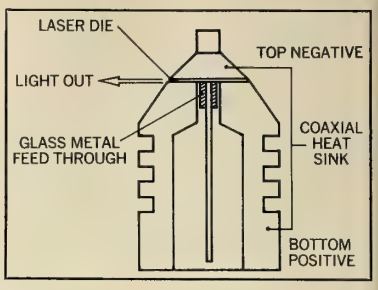

New Product of the Week:
Gallium Arsenide Laser

Gallium arsenide laser systems that operate at room temperature are available from Korad Corp., a subsidiary of Union Carbide Corp.

The KR-1 system, consisting of a laser diode and pulser, has a maximum peak power output of 4 watts with a 50-nanosec. pulse width. Repetition rate range is 10 to 1,000 pulses per second. Spectral output is 8,650 to 8,750 Angstroms, depending on power dissipated at the junction of the crystal. Linewidth is 13 Angstroms. The KR-2 system has a maximum peak power of 1.5 watts.

The crystal is pressure-welded to a copper header with a total device capacity of 10 picofarads. In durability tests, the laser has been operated at 2 watts at 100 pps for seven hours without power degradation, the firm reported.

Circle No. 151 on Subscriber Service Card

Proximity Sensor/Measurer

A non-contact, mass sensing system for complete static and dynamic sensing for diagnosis or production has been announced by Electro-Systems Div. of Turbo Machine, Inc.

The Model ED 136 converts physicay displacements measured by a sensor into visual or signal format for display, test, measurement or control. Measurements as small as 1 microinch are possible.

The portable unit has an operating temperature range of —420° to 2,000°F. Remote operation is possible up to 1,000 ft. Any solid or liquid, conductive or non-conductive mass can be sensed, the firm says.

Circle No. 152 on Subscriber Service Card

Encoder

A audio frequency generator that generates the first 20 IRIG frequencies used for command control is being marketed by Babcock Electronic Corp.'s Aerospace Div.

The Model BCC-30 encoder has a solid-state design for reduced input requirements and can be used to modulate a command transmitter or signal generator. Coder output is variable up to 1.5v RMS into a 500-ohm load. A front-panel switch permits selection of compressed or noncompressed mode. Under compressed operations, up to 20 channels may be operated simultaneously.

The device has an input of 115v ac, 50 to 400 cps, or 28v dc and is designed to military specifications.

Circle No. 153 on Subscriber Service Card

Time-Spread Coder

An error-correcting encoder and decoder has been developed by Westinghouse Defense and Space Center's Surface Div.

The TSC-4 can be used with any type of modulation equipment and operates independently of the transmission frequency. The device consists of four duplex encoder and decoder channels, an encoder synchronization circuit and a decoder synchronization circuit. It meets specifications of MIL-STD-188 and FED-STD-222.

Circle No. 154 on Subscriber Service Card

Reaction Dynamometer

A servo torque-balance reaction dynamometer, said to be 100 times more sensitive than previous units, has been announced by McFadden Electronics Co.

The Model 114A consists of an air-bearing-supported test specimen mounting platform, servo controller and interconnecting cable. Output is displayed in

gm-cm on panel meter and can be displayed on an oscilloscope or recorder.

Torque range is zero to 10 gm-cm with less than 0.0005 gm-cm threshold. Meter display is in three scales: 0 to 0.1; 0 to 1.0 and 0 to 10.0 gm-cm.

Circle No. 155 on Subscriber Service Card

Bidirectional Counter

Janus Control Corp. is marketing a 500-kc bidirectional counter, the Model 658.

The all-silicon instrument offers seven digits with polarity sensing and can reverse without error at the maximum counting rate, developers say. It operates from two input signals in quadrature with input levels down to 100 millivolts peak. The device measures 3.5 x 14 x 17 in.

Circle No. 156 on Subscriber Service Card

Receiver Head

An RF front-end receiver head for laboratory testing of C-band signals is available from Trak Microwave Corp.

The unit measures 5.75 x 8.25 x 4.24 in. Tangential sensitivity averages 87 dbm from 5.2 to 6.0 gc; mixer passband characteristics are greater than 5 to 6 gc. The device can be redesigned to meet specific test requirements, including L-, S- or X-band frequencies.

Circle No. 157 on Subscriber Service Card

Inverter-Converter

A solid-to-liquid cooling static inverter-converter, designed to eliminate interface problems between the power source and power conditioning system in ECM systems, has been announced by Data and Controls Div. of Lear Siegler, Inc.

The Model SIS-3-710242 is built to military specifications and produces outputs of 115/200v, 4-wire, 3-phase at 3,200 cps $\pm 1\%$ at 1 kva, 300v dc at 0.5 amps or 150v dc at 1 amp, from 28v dc input.

Circle No. 158 on Subscriber Service Card

Viscometer

A cone/plate viscometer for measurement of physical characteristics and flow behavior of complex materials is available from Ferranti Electric, Inc.

Basic components of the device are a cone with an angle of 0.3 degree and a flat plate. With the substance under study between the cone and plate, the cone speed ranges from 0.1 to 10, 0.1 to 100 and 10 to 1,000 rpm, providing continuously variable shear rates between 2 x 10^{-2} and 2 x 10^{4} reciprocal seconds.

Micrometer adjustment of gap settings is provided.

Circle No. 159 on Subscriber Service Card

The Space and Information Systems Division of North American Aviation

SYSTEMS TEST ENGINEERING

Employment opportunities are now available for both engineers and senior engineers who possess a background in systems test. These positions will require specialized training and experience on various major systems of the spacecraft.

The Engineering level positions will be responsible for assisting in the preparation of systems checkout procedures for the conduction of specialized tests including individual, combined, and integrated mission tests. Will also assist in pre-test configuration and post-checkout analysis and reports.

The Senior Engineering level positions will direct the preparation of the test operations plan for specialized systems within the spacecraft. Will also plan and develop required operational checkout procedures to conduct individual, combined, and mission readiness systems testing. Responsibilities will also include preparing and directing these tests, determining pretest configuration, and analyzing reports.

These duties will be applied to the following specialized systems:

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- **GUIDANCE AND NAVIGATION**

A minimum of a BS in ME, AE, Chem. E. or EE is required, as well as recent experience in missile and/or spacecraft systems test. Additional experience in engineering R&D and/or engineering design would be beneficial.

To explore these and other professional engineering opportunities, please submit your resume to Mr. B. F. Mantel, Engineering and Scientific Employment, 12214 Lakewood Blvd., Downey, California. All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

North American Aviation
Space & Information Systems Division

At the AIAA Show, July 26-29

missile/space daily will provide complete coverage:

news

Ten editors, under the direction of Bill Coughlin, VP and Editorial Director of AMERICAN AVIATION PUBLICATIONS, and Bill Hall, Editor of MISSILE/SPACE DAILY will be at the Show reporting all important developments.

advertising

During the four days of the show, MISSILE/SPACE DAILY will provide exhibitors and non-exhibitors an outstanding opportunity to sell their products and capabilities with low-cost advertising.

● only official newspaper

MISSILE/SPACE DAILY will publish a tabloid size newspaper during the four days of the AIAA Show. It is the only official newspaper of the show.

● 16,000 circulation

Your advertisement in MISSILE/SPACE DAILY will reach over 16,000 leading Missile/Space/Military/Aviation buying influences.

● pre-breakfast delivery

MISSILE/SPACE DAILY will be delivered daily, before breakfast, to each room at the show hotels. In addition, distribution will be made at the Civic Center where the exhibits will be held.

● 25% discount

Advertisers using the July 19, 1965 Pre-Show Issue of MISSILES AND ROCKETS earn a 25% discount on advertising appearing in the daily newspaper.

MISSILES AND ROCKETS is offering a unique opportunity to get extra impact at low cost before and during the AIAA Show. Advertisers placing a one-page or larger ad in the AIAA Section of MISSILES AND ROCKETS July 19, 1965 issue will automatically earn a 25% discount on advertising run in MISSILE/SPACE DAILY.

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**45,000 regular paid circulation in MISSILES AND ROCKETS, 16,000 in MISSILE/SPACE DAILY.*

MISSILE/SPACE DAILY — **PUBLISHING DATES: JULY 26, 27, 28, 29**

ADVERTISING CLOSES: JULY 12

MISSILES AND ROCKETS — **PUBLISHING DATE: JULY 19, 1965**

ADVERTISING CLOSES: JULY 6, 1965

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John H. Dillon: Named special Washington consultant for FMA, Inc., Los Angeles. Dillon has served as special assistant to 13 Secretaries of the Navy and has twice won the Navy Distinguished Civilian Service Award.

Jack Linzie: Named vice president and general manager of Aeronca Manufacturing Corp.'s Aerospace Div., Baltimore. He had been vice president of public relations and personnel. Linzie joined Aeronca in 1940 as director of industrial relations.

Seymour Katz: Elected president of Datatron Laboratories, New York City. Previously, he was marketing manager for Defense and Space Div. of Barnes Engineering Corp.

Charles R. Upton: Elected vice president for engineering of the Schonstedt Instrument Co., Silver Spring, Md. He joined the firm in 1961. Prior to that, he was associated with Atlantic Research Corp.

Charles G. Smith: Named vice president-marketing of Electron Products Div. of Marshall Industries, San Marino, Calif. Before joining Marshall, Smith served as regional sales manager for Electra Manufacturing Co.

Eugene L. Rogers: Joined Memorex Corp., Santa Clara, Calif., as director of corporate planning. The post is a new position responsible to the president for several staff functions.

Gordon O. Pehrson: Elected to the board of directors of Operations Research, Inc., Silver Spring, Md. He is presently a vice president of International Minerals and Chemical Corp.

Andrew McCulloch: Named vice president of L. T. Industries, Inc., Garland, Texas. He was previously associated with Ling-Temco-Vought, Inc.

Adrian J. Vaksvik: Elected president of CTS of Paducah, Inc., Paducah, Ky. He previously served as vice president and resident manager of the firm. It is a subsidiary of CTS Corp., Elkhart, Ind.

Berkley J. Baker: Appointed director of public relations and advertising for Teledyne, Inc., Hawthorne, Calif. He was previously associated with Litton Industries, Inc.

Donald R. Mitchell: Appointed executive vice president of Burton Manufacturing Co. and also elected to the company's board of directors. Mitchell will be responible for operations at Burton's Van Nuys, Calif., plant.

William Olander: Named manager of marketing of Computer Test Corp., Cherry Hill, N.J. He formerly was with IBM Corp.'s Federal Systems Div.

Joseph W. Mintzer: Joined International Resistance Co., Philadelphia, as corporate promotion manager. He succeeds Walter H. Canfield, who has been named general manager of the firm's new Consumer and Distributor Products Div.

Robert A. Posner: Promoted to product manager of ITT Corp.'s Data and Information Systems Div., Paramus, N.J. He formerly served with the firm's U.S. Defense Space Group headquarters.

Lou Bernard: Elected vice president of marketing and sales for Dynamic Instrument Corp., Plainsview, N.Y. He formerly served as director of marketing and sales.

John L. Salladin: Appointed director of marketing for Tally Corp., Seattle, Wash.

Ronald L. Ward: Joined engineering staff of Research & Development Dept. of Misco Precision Casting Co., Whitehall, Mich.

In the long run
(between Los Angeles and Cape Kennedy)
it pays to be direct.
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National Airlines jets you directly (no changing planes)
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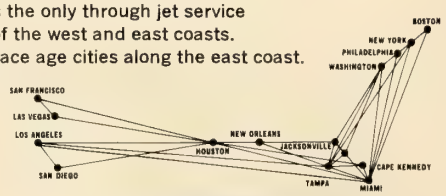
between major space centers of the west and east coasts.
National also serves the key space age cities along the east coast.
Are we putting you on?



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Coast to Coast to Coast

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—when and where—

JUNE

26th Paris International Air Show, Le Bourget, Paris, June 10-21.

Ocean Science and Ocean Engineering Conference and Exhibit, sponsored by the Marine Technology Society and the American Society of Limnology and Oceanography, Washington Hilton Hotel, Washington, D.C. June 14-17.

Propulsion Joint Specialist Conference, sponsored by the American Institute of Aeronautics and Astronautics, Air Force Academy, Colorado Springs, Colo., June 14-18.

International Symposium on Multivariate Analysis, sponsored by the Aerospace Research Laboratories (Air Force), Dayton, Ohio, June 14-19.

Tenth Anniversary Scientific Seminar, sponsored by the Air Force Office of Scientific Research in cooperation with the University of New Mexico and the Air Force Missile Development Center, Cloudcroft, N.M., June 14-25.

1965 Heat Transfer and Fluid Mechanics Institute sponsored by the American Institute of Aeronautics and Astronautics, Los Angeles, June 21-23.

Eighth Annual Conference on Vacuum Metallurgy, sponsored by the American Vacuum Society, Barbizon Plaza Hotel, New York City, June 21-23.

1965 Aerospace Technical Conference and Exhibit, sponsored by the Professional Technical Group on Aerospace and the Institute of Electrical and Electronics Engineers, Shamrock-Hilton Hotel, Houston, June 21-24.

21st Annual Meeting of the Institute of Navigation, Edgewater Inn Marina Hotel, Long Beach, Calif., June 21-23.

73rd Annual Meeting of the American Society for Engineering Education, Illinois Institute of Technology, Chicago, June 21-24.

Seventh Biennial Conference on Carbon, sponsored by the American Carbon Committee, Case Institute of Technology, Cleveland, June 21-25.

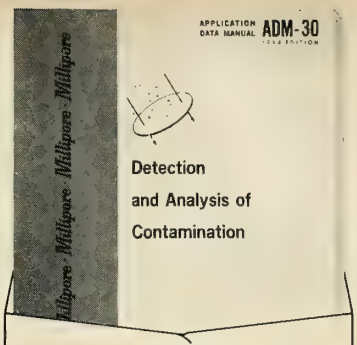
Fourth Annual Seminar on "Energetics in Metallurgical Phenomena," sponsored by the University of Denver and the National Science Foundation, University of Denver, Colo., June 21-Aug. 13.

1965 Joint Automatic Control Conference, Rensselaer Polytechnic Institute, Troy, N.Y., June 22-25.

Symposium on "Fluid Mechanics and Heat Transfer under Low Gravitational Conditions," sponsored by the Air Force Office of Scientific Research and Lockheed Missiles & Space Co., Palo Alto, Calif., June 24-25.

Ninth National Conference on Aerospace Education, sponsored by the National Aerospace Education Council, Hotel Mayflower, Washington, D.C., June 24-26.

Annual Meeting of the National Society of Professional Engineers, Western Skies Motor Hotel, Albuquerque, N.M., June 30-July 3.



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Kenneth C. Blanchard, Director of Research and Marketing

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Paul B. Kinney, Eastern Advertising Manager
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On Walking and Talking

THE FOUR-DAY FLIGHT of *Gemini 4*, with its remarkable space walk by astronaut Edward White, will some day seem such an elemental event that the wonder will be that it attracted concentrated worldwide attention.

Men then will be making regular journeys to the Moon and other planets and will be working routinely in space outside their laboratories and spacecraft.

Today, however, the wonder of the accomplishment still exists. No one can fail to take pride in the pioneering space venture of astronauts White and James McDivitt. No one can fail to share the exhuberance shown by Ed White as he floated weightless more than a hundred miles above his Texas home. No one can seriously criticize the sheer joy that kept him outside the capsule longer than scheduled.

But there are indeed some serious observations to be made concerning the flight and its value to the U.S. space program. It marked several major milestones in the rapidly maturing space effort and developed information of considerable future value.

The flight did not, as some have suggested, put the U.S. ahead of the Soviet Union in space. It did demonstrate that the competition is somewhat closer than it has been. Furthermore, it was demonstrated on a worldwide scale, thanks to the *Early Bird* communications satellite, which enabled additional millions throughout the world to share the tense moments of an actual liftoff.

That these millions can now identify with the U.S. space program, as Madison Avenue might say, is a major propaganda asset for the U.S. The impact of this will not be lost on the Russians. Live television coverage of a future Soviet launch must be counted a strong possibility.

But the U.S. propaganda victory and exhilaration over success of the flight must not be allowed to obscure the fact that we still have a long way to go in catching up with the Soviets.

Gemini is a very small vehicle compared to the large Russian spaceships. The Soviet Union already has orbited three men in one ship, something the U.S. will not accomplish until the *Apollo* program. Live television from space is a Russian exclusive, prohibited in *Gemini* by size limitations. The cramped nature of *Gemini* was made adequately clear on the recent flight, both by the comments of the astronauts and by the necessity to postpone the extravehicular activity for one orbit.

The Russians accept a shirtsleeve environment in their craft as a matter of course while U.S. astronauts sweat it out in spacesuits. There is ample room in *Voskhod*, moreover, to don or doff a spacesuit in flight. An airlock makes it unnecessary to dump cabin pressure each time extravehicular activity takes place.

We do not wish in any way to detract from the magnificent achievement of *Gemini 4*, but its accomplishments must be kept in perspective. There is much still to be done.

An aid to future success will be the great mass of medical data accumulated as a result of the four-day flight. The U.S. now has an extended flight of its own on which to base medical judgments, thereby freeing *Gemini* and *Apollo* planners from dependency on the scanty data supplied by the Russians. This is a major step forward.

The National Aeronautics and Space Administration has been severely criticized for its last-minute decision on extravehicular activity in the *Gemini 4* mission, with the implication that it was either risking the lives of the two astronauts in an effort to pull off a headline stunt or that it had not been bold enough in its original planning.

We disagree with that view. We believe the EVA decision demonstrated considerable maturity, showing that the U.S. program has reached a point where there is sufficient confidence so that new inputs now can be made when desirable without years of planning.

The EVA decision was not a hasty one. EVA plans for *Gemini 4* called for White to open the hatch and stand up in his seat. Once Soviet cosmonaut Alexei Leonov demonstrated that the next step provided no additional complications, the decision to have White get out of the capsule was a natural one. EVA equipment and the spacesuits had been thoroughly tested. The astronauts had been practicing EVA simulation for some time, even prior to Leonov's walk in space. With depressurization of the capsule and opening of the hatch already scheduled, there certainly was little additional danger in having White step outside.

Such innovations in the program, when carefully considered, should be welcomed, not criticized. The U.S. pace must be geared to knowledge, not to a preplanned script.

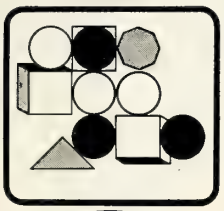
WHAT WE DO heartily condemn is NASA's approach to the EVA question in regard to the press. Newsmen, in Washington and elsewhere, were deliberately lied to by NASA officials, who stated that no plans for White to egress from the capsule were under consideration at a time when the truth was just the opposite. Under pointed questioning, *Gemini* Program Manager Charles W. Mathews made just such a statement to the Aviation/Space Writers Assn. meeting in Albuquerque—only four days before the announcement that White would leave the capsule. This left an impression that he was uninformed, which is ridiculous, or he was lying, which is despicable. Mathews later told M/R he had been unable to discuss EVA plans because they had not been approved.

There is no need for such a policy and we hope Administrator James Webb will take steps to end it at once. Pettiness should not be allowed to mar such a spectacular achievement.

William J. Coughlin

LET'S SWAP RESUMES

New programs ranging from microminiature circuitry to complete manned spacecraft design and production have created many openings in Design and Electronics through the Managerial level. Experienced men are needed for such programs as GEMINI • PHANTOM II • ASSET • STOL TRANSPORT • CAPSULE ESCAPE SYSTEMS • BOOST-GLIDE REENTRY VEHICLES • PHOTO INSTRUMENTATION EQUIPMENT & SYSTEMS • AIRFRAMES & ENGINES • ELECTRONIC SYSTEMS & EQUIPMENT.



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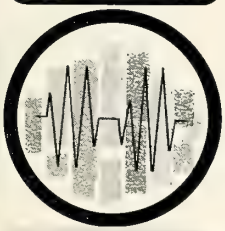

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missiles and rockets

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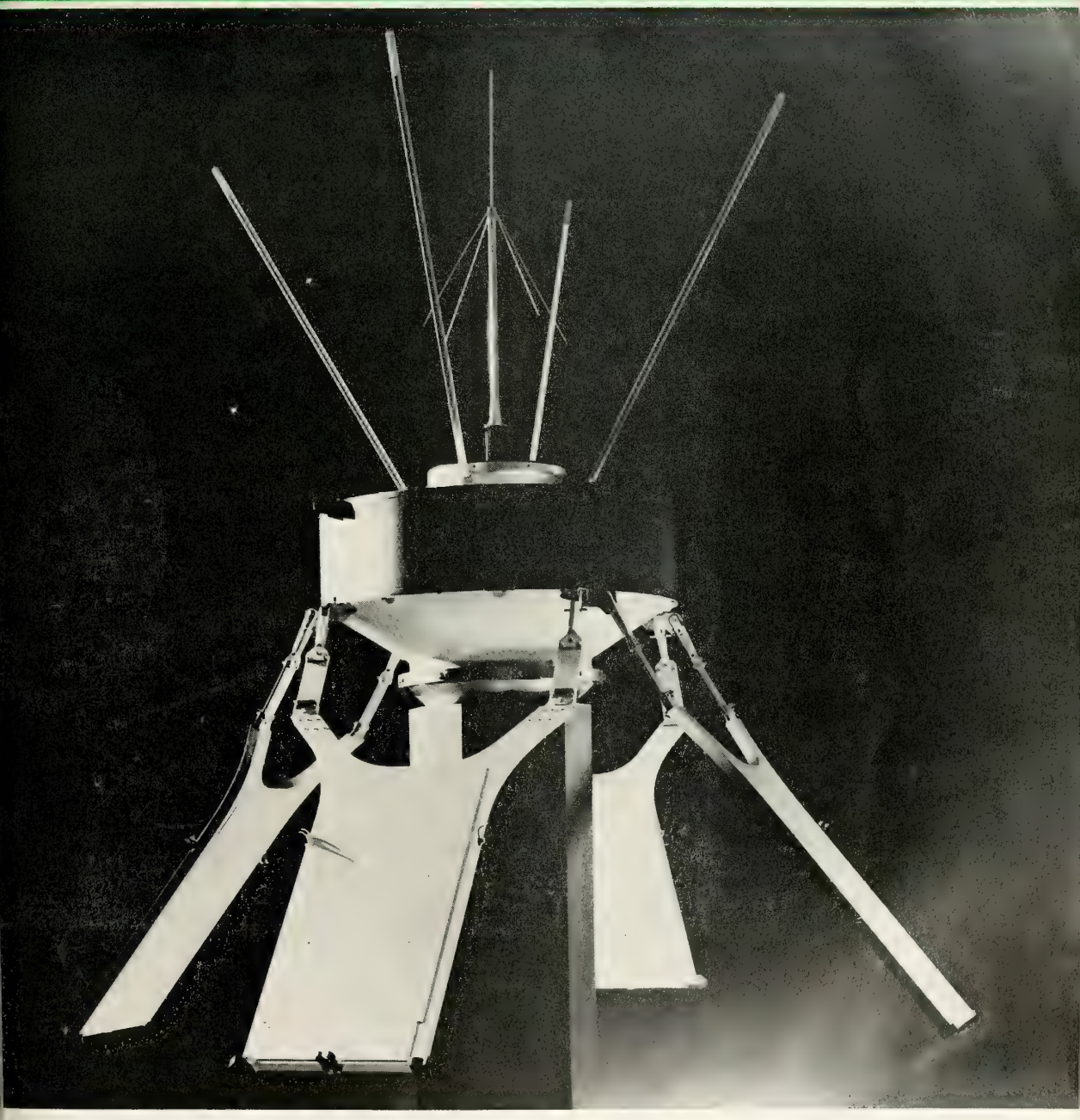

Model of France's D-1 Satellite at Paris Air Show

Two Firms Likely for AES Integration

Part I of Report on Paris Air Show

Keltec Develops Unique Comsat Ant

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This JT4 is not scheduled for another overhaul for 3,000,000 miles.

The Federal Aviation Agency recently authorized an increase in the time between overhaul of the Pratt & Whitney Aircraft JT4 engine to a new high level of 6,200 hours.

This authorization, to Pan American World Airways, means that the JT4 may power aircraft 3,000,000 miles between overhauls. These engines, in service nine hours every day, will not require overhaul for 22 months.

The FAA has increased TBO authorizations for Pratt & Whitney Aircraft turbofans at even faster rates. The military turbofans have also shown remarkable improvements in operational service.

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missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 25 June 21, 1965

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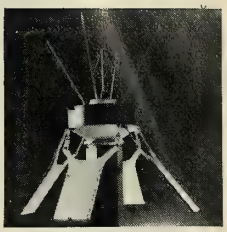
THE COVER

France's D-1 satellite model, one of many displays emphasizing the maturation and intensity of that nation's space exploration at the Paris Air Show. The satellite is to be launched in 1966. The first of a two-part M/R report on the international exhibition begins on p. 16.



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ELECTRONIC ENGINEERS

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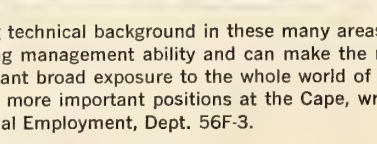

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letters

Ranger Appreciation

To the Editor:

Re: "Moon Struck" (editorial), M/R, April 12.

People may get the impression that the scientists who evaluated the *Ranger* photographs do not agree with each other as to the nature of the lunar surface. If one read the technical report (JPL TR No. 32-700, *Ranger VII*, part II, Experimenters' Analyses and Interpretations, Feb. 10, 1965) carefully, he would find astonishing agreement among the scientists. This is especially true for the systematic and detailed reports by Professor Kuiper and by Dr. Shoemaker.

People may not realize that the most difficult mission of the *Ranger* project is to shoot the spacecraft to a predetermined target on the lunar surface. The most difficult mission of the *Surveyor* project is to learn the advanced art of soft-landing on the lunar surface, and not for the TV camera to take more pictures. Without previous *Ranger* experience, *Mariner 2* and *Mariner 4* may fail. We are proud of our space program, which has created a new era in American history.

James M. S. Sun
Albuquerque, N.M.

One Man's 'Million'

To the Editor:

In the correspondence section of your June 7 issue, under the headline "Hazards of Brevity," Mr. C. Dean Hermansen takes Mr. William A. Koch to task for suggesting "mpt" as a good abbreviation for million-pound-thrust.

Mr. Hermansen then goes on to point out that "the International Committee on Weights and Measures has recommended, and is backed by long-standing practice, that M (capital) be used for abbreviating million."

I would ask Mr. Hermansen, "Whose long-standing practice?" I have always been under the impression that "M" (from Latin "mille") was the generally accepted abbreviation for *thousand*. At least, so it is in the advertising and marketing business in Canada and the U.S., an industry which is not exactly unfamiliar with "Initialese." For example, "cost per thousand" is abbreviated "CPM."

I would suggest to Mr. Hermansen that "M^2" would be a logical abbreviation for million. At least, this would be consistent with the practice, long in use in scientific circles and now becoming rather common in the world at large, of expressing large numbers exponentially.

Bryant A. Langmuir
Vice President and
Account Supervisor
Kenyon & Eckhardt, Ltd.
Toronto, Ontario, Canada

We're not taking sides, but would note that practice now is to use "m" for thousands, "M" for millions.—Ed.

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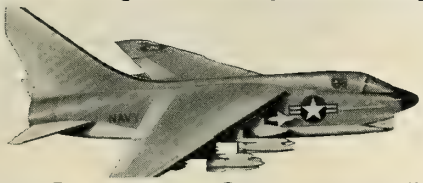
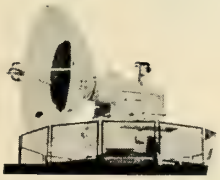
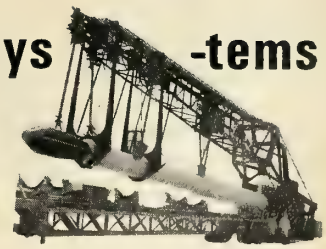
Put briefly, it is a diversified aerospace company that traces its aeronautics manufacturing history to 1917, but through its store of engineering and scientific brainpower, experienced management and investments in research and development produces some of the most advanced products and services today in the fields of aeronautics, missiles, space, ground vehicles and range and launch operations management. /For example: Aircraft such as  the A7A, the Navy's new light attack aircraft . . . and the XC-142A, the world's largest flying V/STOL . . . Missiles such as the Army's new Lance Battlefield Missile . . . Astronaut Maneuver-ing Space Packs such as M.M.U. for Project Gemini . . .  Range and Launch operations and services through its Range Sys-tems division . . . Rockets such as NASA's  Scout research rocket . . . and Ground Vehicles such as the Army's new XM-561.

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The Countdown

WASHINGTON

McNamara Okay for MOL Program Awaited

Presidential science adviser Dr. Donald F. Hornig has been briefed by the Air Force on the *Gemini*/Can *Manned Orbiting Laboratory* configuration and is reported to be impressed with the program. There appears to be no opposition in Congress or elsewhere, and a final decision now rests with Defense Secretary McNamara, who was briefed early last week. Announcement of a go-ahead on the program is believed to be imminent.

Webb Undecided as to Supplemental . . .

Question of whether NASA should ask for a supplemental spending authorization for Fiscal Year 1966 appears to be open. Administrator James E. Webb says the matter will have to be examined after the final appropriations figure is handed down by Congress.

. . . But Wants Full $5.19 Billion

Webb has told the Senate Independent Offices subcommittee, now considering the space agency's appropriations legislation, that NASA simply cannot operate at the $5.16-billion level voted by the House Appropriations group. He made a strong plea that the entire authorization figure of $5.19 billion be voted, on grounds that that figure represented the minimum feasible, and was reached through reductions before the budget was ever submitted to Congress.

JPL Due to Get Voyager Lander Management

NASA is expected to confirm in about two weeks that Jet Propulsion Laboratory has been selected to manage development of the *Voyager* spacecraft's capsule lander. This will give JPL overall responsibility for the spacecraft system, while Marshall Space Flight Center will direct the *Saturn IB*/*Centaur* launch vehicle.

Manned Flight on 30 Days' Notice

Dates for manned spaceflights henceforth will be announced 30 days in advance of liftoff. Previously, dates for such missions were embargoed until 10 days before launch. Policy change was made by NASA Associate Administrator Robert C. Seamans.

First S-IVB Flight Stage Nears Cape Trip

The S-IVB stage for the first *Saturn IB* flight early next year is now scheduled for shipment to Cape Kennedy late in August. Stage acceptance firing is slated for next month. A test stage to be used in checking out readiness of *Saturn IB* and *Saturn V* launch facilities is already en route to the Cape via Panama Canal, and should arrive about July 2.

Complex To Be Beefed Up for Saturn IB

Bids will be opened June 24 on modification work to prepare *Saturn* Complex 37 at Cape Kennedy for the *Saturn IB* program. It is expected to cost $4.5 million. To accommodate the *IB*, 33 ft. longer than *Saturn I* and weighing an additional 130,000 lbs., the gantry will be reinforced with 120 tons of steel and two new four-wheel trucks will be added under each of the two front columns.

Setback for Contracts-by-Geography

Congress has backed off a bit from a move by members of the House Space Committee to get NASA to consider geographical distribution of funds in awarding its R&D contracts. Conferees of House and Senate committees working on the NASA authorization bill decided to accept the Senate version, which makes clear that present Government procurement policy is not to be materially altered.

INDUSTRY

Marquardt To Study Composite-Cycle Power

NASA has awarded a $250,000 contract to Marquardt Corp. for a study to provide technical guidance for R&D aimed at design of composite-cycle propulsion systems for advanced launch vehicles. Having both air-breathing and rocket components integrated into a single system, such engines could provide payload performance significantly higher than that of conventional rockets. Rocketdyne and Lockheed California Co. are associated in the program.

Phoenix Antenna by Electron Beam

Hughes Aircraft Co.'s Culver City (Calif.) plant is fabricating planar array antennas out of 0.016-in. magnesium for the *Phoenix* missile system. To join sheets of this thinness, one of the world's largest electron-beam welding machines has been installed for the in-house program. Built by Sciaky, it has a 62 x 55 x 55 in. vacuum chamber that evacuates up to 5 x 10^{-5} Torr in six minutes. Continuous welds of up to 50 in. can be made at speeds up to 100 in. per minute. Machine has welded 1-in.-thick maraging steel and two-in. aluminum, and is being tested on 6-in. aluminum stock.

INTERNATIONAL

TRW STL, Matra Forming Paris Firm

TRW Space Technology Laboratories and the French company Engins Matra have decided to form a jointly owned French firm—called Matrel—to bid on systems and missions analysis and systems engineering of European space projects. Both U.S. and French governments would have to approve the move, and French law requires that Matra have majority ownership. Some STL personnel would be transferred to Paris to assist in establishing Matrel. Engins Matra is active in the tactical missile field, but spokesmen say the new agreement is limited to space activities. In that area, Matra is involved with the *D-1* satellite being developed for the French space agency and is a major subcontractor to Hawker Siddeley Dynamics for the *ESRO II* satellite.

British Aim at Bigger Skua Stable

Engineers at Bristol Aerojet, Ltd., in England say they expect to begin flight trials next February of their new *Skua* 7.5-in.-dia. research rocket. The new version would lift the capability of the existing widely used *Skua* family to altitudes of 150 km and payload weights of about 12 kg.

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NASA Bill Due Final Action

NASA's authorization bill reached final action last week with the passage through the House of the conference bill, which provides for $5.190 billion. Senate action was expected soon after.

The bill, resulting from compromise between the House and Senate Space Committee recommendations, provides funds for the M-1 engine at $7.5 million, and SNAP-8, $6 million, which were not requested by the Administration. Language in the conference bill restricts NASA's use of this money to these programs alone, forestalling any reprograming to other project areas. The 260-in. solid rocket motor program was not in question in the conference since both the House and Senate had voted to fund this at $6.2 million.

Other good news for NASA was the decision to allow $5 million in construction funds for the Electronics Research Center. The Senate had voted $10 million for this, the House none.

The House also agreed to the Senate action in restoring funds cut by the House for the *Orbiting Geophysical Observatory*. The House took the position that the *OGO* launch schedule is overly ambitious, but the Senate felt that *OGO* was vitally important to the *Apollo* program.

The Senate accepted the House version on *Apollo*, which amounts to a $30-million cut in the program. The Senate previously had voted to cut the *Apollo Extension Systems (AES)* program by $24 million or one-half.

A $3-million cut made by the House in the $4-million fund for launch vehicle development supporting research and technology was retored as in the Senate bill. In the tracking and data acquisition category, the Senate agreed to the lower House figure of $242.3 million. Senate action in cutting the technology utilization fund by $250,000 was accepted by the House, reducing it to $4,750,000.

On construction, the conferees agreed upon a figure of $62.3 million. Administrative operations were funded at $591,048,850, almost a direct split between House and Senate versions.

SNAP-25 Prime Chosen

Lockheed Missiles and Space Co. and Nuclear Materials and Equipment Corp. have been selected by the Atomic Energy Commission for negotiations on the design, development, fabrication and ground test of a new SNAP device.

There are as yet no definite applications for the nuclear generator, to be known as SNAP-25, but it might find use as a spacecraft power generator.

The plutonium-238-fueled, 75-watt device is expected to be under development for 2 years, and it is anticipated that the program will cost $5.75 million through ground test.

The LMSC-NM&E team was picked from three bidders on the program, which also included RCA's Astro-Electronics Div. and General Electric's Missile and Space Div. RCA will serve as a major subcontractor to the joint venture, working on development of the thermoelectric conversion system.

F-1 Engines Fired

The five F-1 engines of the *Saturn V* ground test booster (*S-1C-T* stage) were fired successfully for 90 seconds June 11 at the Marshall Space Flight Center. The firing developed the *S-1C*'s rated 7.5 million pounds thrust.

All four outer engines were gimballed or swivelled in the test, simulating the motion required to control the vehicle in flight. A full-duration 2½-min. firing is scheduled for mid-July.

Uprated Atlas Okayed

NASA has announced that it has approved a program to develop a more powerful *Atlas* space booster for future *Agena* and *Centaur* missions (M/R, May 17, p. 14).

The launch vehicle, presently designated the *SLV-3X*, will be uprated by increased fuel capacity and engine changes that will result in a 600-lb. payload increase in lunar missions using the *Centaur* upper stage.

Propellant capacity will be increased by some 21,000 lbs. by making the top of the vehicle cylindrical rather than a truncated cone. The increased tankage will enable the *Atlas* to carry 15,000 lbs. more liquid oxygen and nearly 7,000 lbs. more RP-1, a highly refined kerosene fuel.

Thrust of the three *Atlas* engines will be increased by use of an improved fuel injector and turbine. Use of a modified *Saturn* H-1 injector will increase the total thrust of the two booster engines from 330,000 lbs. to 350,000 lbs. Use of an already-developed turbine will increase thrust of the sustainer engine from 57,000 to 65,000 lbs.

The work will be done by the Convair Div. of General Dynamics, San Diego, Calif. The Air Force's Space Systems Div. is the procurement agency acting as NASA's agent as in previous NASA procurements of the *Atlas*.

Aerojet Big Solid Loaded

Aerojet-General Corp.'s Dade Div. on June 15 completed propellant loading in the first of its 260-in.-dia. half-length engines.

The half section was loaded in a little more than a week. With 1.6 million lbs. of propellant, it is probably the largest solid loading to date in the free world, more than three times the amount (440,000 lbs.) in one of the 120-in. solid segments that form part of the five-segment strap-on for *Titan III-C*.

SUBROC Deployment Nears

The *SUBROC* underwater-to-underwater anti-submarine weapon has taken a long stride toward deployment in all U.S. nuclear-powered attack submarines.

Operational test firings of the rocket-powered *SUBROC* have been completed successfully and on schedule, it was announced June 15 by Goodyear Aerospace Corp., prime contractor for the weapon.

A number of *SUBROC* missiles were launched recently from the USS Plunger (SSN 595) in the mid-Pacific Ocean. The crew of the nuclear attack submarine achieved a very successful score on "missiles on target" during the test series, encompassing complete tactical ranges and depths, Goodyear officials say.

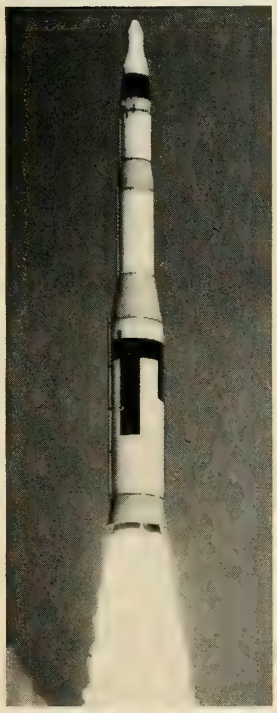
SUBROC was developed by Goodyear Aerospace for the Bureau of Naval Weapons under the technical direction of the Naval Ordnance Laboratory, White Oak, Md.

Soviet Moon Probe Fails

Luna 6, the Soviet Moon probe, missed its target by about 96,000 mi. following a steering malfunction on June 9.

According to Tass, the Russian news agency, the rocket strayed off course after an engine used for a correction maneuver failed to turn off. The spacecraft, launched from a satellite in Earth orbit on June 8, was originally scheduled to impact on the Moon on June 10.

Computer Systems Engineering Openings



Computer Center, Seattle

The Boeing Company's Aero-Space Division — major contractor for the NASA Saturn V launch vehicle, USAF Minuteman ICBM and NASA lunar orbiter — has a number of challenging openings for qualified graduate computer systems engineers. Requirements are a B.S., M.S., or Ph.D. in engineering, physics or mathematics, preferably with experience in computer applications, computer systems analysis or related fields.

These assignments are at the Boeing Computer Center in Seattle, one of the largest and most complete industry computer facilities in the free world. Additional positions are available at Huntsville, Ala. and New Orleans, La.

Computer Applications — Develop digital computer systems for calculating trajectories and trajectory optimization, guidance and control, loads and stresses, and temperature distributions.

Design and implement real time and near real time spacecraft performance computer programs. Assignment will involve coordination with other contractors and participation in space flight control.

Analyze and design computer programs and information processing systems to be used in support of operational command and control systems. Experience in the fields of information retrieval or query languages is desirable.

Computer Systems Analysis — Evaluate, develop and implement programming languages and compiler systems for scientific computing systems. Experience in large scale systems, design and development of compilers or major applications programs is desirable.

Develop and implement software systems for small and medium size computers used for on-line data acquisition and processing, military and space systems simulation and crew training simulators.

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Poseidon Pact Made

A $331,000 study contract on the guidance electronics package for the *Poseidon* missile has been awarded Raytheon Co. by the Navy's Special Projects Office.

Contract also calls for Raytheon to provide industrial support to the MIT Instrumentation Laboratory, design agents for the missile's guidance system.

Raytheon will work on cost projections and other advanced planning for the computer, servos, power supplies and other electronics that are part of the airborne missile guidance system.

Raytheon's participation in the *Poseidon* program will be managed by the Space and Information Systems Div., Sudbury, Mass.

Mariner Makes Last Correction

The *Mariner IV* spacecraft on June 14 successfully performed a final tracking correction before its encounter with Mars on July 14.

The Jet Propulsion Laboratory said that there was no spacecraft maneuver involved, nor any ground command necessary. The correction was made as a result of a command pre-programmed into *Mariner's* central computer and sequencer.

Power to spare is expected on the craft at Mars. No degradation of its solar panels has occurred to date, and they are calculated to yield 300 watts at time of Mars flyby. At that time the spacecraft's electrical load will be only 200 watts.

FCC Awaits Comsat Reply

Communications Satellite Corp. has until June 25 to reply to the Federal Communications Commission in defense of its right to own and operate the initial U.S. ground stations for satellite communications.

At least six common carriers have registered objections to the recent FCC ruling which gave Comsat sole responsibility for three new ground stations (M/R, May 17, p. 11). Those filing comments included American Telephone & Telegraph Co., International Telephone and Telegraph Corp., Western Union International, Hawaiian Telephone Co., General Telephone & Electronics and the U.S. Independent Telephone Assn. Following Comsat's reply, the carriers will have a week to file an answer with the FCC.

Shots of the Week

The Air Force launched the second of four Stellar Acquisition Feasibility Flight (STAFF) shots on June 15 from Cape Kennedy. Preliminary data indicated that all test objectives were met.

The flight, aboard a modified *Polaris* booster, was originally programmed for nighttime to permit easier acquisition of the North Star. Flying STAFF in daylight was a deliberate acceleration in the schedule, according to a spokesman for General Precision, Inc. The firm makes STAFF, forerunner of a stellar inertial guidance system (STINGS) for the Air Force Ballistic Systems Div.

The guidance acquired the star above the cloud cover, a refinement of the first flight in which STAFF had been locked on to its star prior to liftoff. However, altitude at acquisition and the roll-stabilized booster's entire trajectory were classified.

In both flights to date, STAFF has performed no actual navigation and has ridden open loop. The fact it had been locked in position before liftoff on the first flight April 14 proved STAFF's salvation when the nighttime flight had to be aborted 73 seconds off the pad because of malfunctioning gyros in the *Polaris* second stage.

The second STAFF flight again tested a telescope-like device intended to allow the launching of a missile on an approximate flight path, then taking a reading from a star to plot a more precise trajectory to the target area.

- The Air Force launched two ICBM's from Vandenberg AFB, Calif., June 10, but one, a *Minuteman,* had to be destroyed shortly after launch because of a malfunction. The other, an *Atlas D,* was launched in support of the Army's *Nike-Zeus* program.
- Again at Vandenberg, the Air Force on June 14 successfully launched a *Titan II* ICBM from a silo as part of an operational readiness test.
- NASA called on Washington, D.C., radio station WTOP June 14 for assistance in conducting a radio signal interaction experiment employing a *Nike-Apache* launched from Wallops Island, Va. WTOP transmitted a steady modulated tone for several minutes during the flight to enable University of Illinois scientists to measure the interaction of the WTOP signal on a signal of a different frequency broadcast from Wallops. Both were received by instruments on the rocket as it rose into the ionosphere.

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NASA Ponders AES Integration Team

Dimensions of payload planning job for Apollo Extension are such that two centers and two contractors probably will be chosen

by Hal Taylor

SPACE AGENCY OFFICIALS report that two NASA field centers and two industrial contractors probably will be involved in the payload integration activity for *Apollo* Extension Systems (AES).

The need for multiple teams apparently stems from the large amount of work required for integrating the various payloads to be launched on Earth-orbiting and lunar orbital and surface missions.

A final decision as to which centers and how many contractors is expected to be made in the next 10 days, with requests for proposals going out to industry before Fiscal Year 1965 ends on June 30.

A host of officials from NASA headquarters, the Manned Spacecraft Center, the Marshall Space Flight Center and the Kennedy Space Center are scheduled to meet early this week to prepare various management alternatives for presentation to top NASA management.

At stake is whether the whole AES payload integration work should be managed by the Manned Spacecraft Center and one industrial contractor, or whether another center, probably Marshall, and another contractor should also be made part of the team.

Noting that a final decision still has not been made, a NASA official said that while it would be desirable in the interest of simplicity to have only one field center and contractor involved, the sheer enormity of the job makes it likely that more will be required.

● **Under way**—Once a decision is made, RFP's will be issued for four-to-six-month preliminary program definition contracts. Two to four contractors are expected to be selected for each payload integration job required.

This will be followed by a six-to-eight-month final program definition phase, when one contractor for each payload integration job will be named; this will then be followed by hardware development.

Late last week or early this week, NASA officials were to brief President Johnson's Scientific Advisory Committee, headed by Dr. Donald F. Hornig, on their plans for the AES. The briefing has nothing to do with approval of the program, because both houses of Congress authorized funds for it in NASA's Fiscal Year 1966 budget, when it first appeared as a line item. Early preliminary program definition studies, however, will be funded with Fiscal '66 money.

(For other details of the AES plans see M/R, June 7, p. 17.)

● **Moon packages**—While AES plans were proceeding, the Manned Spacecraft Center asked for bids by July 12 on a group of experiments that will be left on the Moon by Project *Apollo* astronauts.

MSC has reduced to eight the number of such experiments. It is accepting bids from industry on their integration into one Lunar Surface Experiment Package (LSEP).

The following experiments proposed by the scientific community are LSEP candidates, according to MSC:

—Active lunar seismic measurement to study lunar properties to a depth of 500 ft. Five mortars will be fired as seismic sources to empact 200 to 2,000 ft. from the Lunar Excursion Module. A metering line towed by a projectile will measure the range. Two geophones, buried 100 ft. apart, will receive the seismic signals, which will be amplified and carried to the data subsystem.

—Passive lunar seismic measurements to detect seismic waves from natural sources in three axes and over a broad frequency spectrum.

—Lunar gravity measurement to determine acceleration changes due to gravity. Scientists are interested in comparing observed with predicted tidal effects over several months to determine if changes are associated with free oscillation of the lunar surface, possibly excited by seismic activity or driven by interstellar gravitational waves.

—Lunar meteoroid measurement of both primary and secondary meteoroids, using an integrated sensor that can monitor their flux, velocity, radiance, momentum and depth of penetration.

—Heat flow measurement by estimating the magnitude of disturbances in temperature and heat flow due to irregularities in the thickness of the lunar surface layer and variable albedo. The crew will drill holes in the soil rock, lower probes and spread "thermal blankets" over suitable areas.

—Lunar atmospheric measurement to support the study of atmospheric physics of rarefied gases. Analyzers will search the atmosphere for heavy gases, out-gassing of volatiles from the interior of the Moon or from impact by meteorites and high-energy particles, and for exhaust gases left by vehicles landing and operating on the surface of the Moon.

—Lunar radiation measurement to detect solar wind against the lunar surface and to measure its flux, angular distribution and energy; to investigate the internal processes of the Earth's magnetospheric tail and record the flux and energy spectra of solar protons and alpha rays in the 5-mev to 1-bev energy range.

—Lunar surface magnetometer to measure the lunar magnetic field in three axes with well-defined accuracy at one or more locations.

MSC said weight, volume and supporting subsystem limitations will determine which of the candidate experiments will become integrated in the LSEP. ■

June 25 Set for First Hot Test of Phoebus

The Nuclear Rocket Development Station will attempt the first hot test of the Phoebus nuclear reactor on June 25.

The test is scheduled for seven or eight minutes at a power level of about 1,100 megawatts.

The timetable for the test was learned as NASA signed a two-phase $11.1-million contract with Aerojet-General Corp. for development of three exhaust nozzles for the reactor.

The first phase of the contract will include a four-month preliminary design study of the nozzle and a joint design effort with American Car and Foundry, Inc. ACF is the contractor responsible for the pressure vessel. This phase will be on a cost-plus-fixed-fee basis with a value of $1,837,971.

Phase II calls for hardware development under an incentive contract with a value of $9,325,-080.

Oceanography Spending Seen Soaring

Participants at ocean science meeting told that Government sea-study funding will reach $350 million annually by 1972

by William S. Beller

INCREASING Government spending in oceanography and burgeoning industry interest in exploiting the seas brought 1,300 participants to the first Ocean Science and Ocean Engineering Conference in Washington, D.C., June 14-17.

The conference was co-sponsored by the Marine Technology Society and American Society of Limnology and Oceanography.

The nearest open purse for many companies was seen holding $250-$300 million for the Navy's overall deep submergence program over the next five years. Yet this amount was expected to be less than one year's Federal expenditures for oceanography in the early 1970's.

In addition, many hundreds of millions of dollars are expected to be spent and earned over the next decade by the oil industry in offshore drilling and establishing underwater fuel storage facilities, by mining interests trying to take minerals from the sea, and by industry erecting power plants and desalination plants on artificially created islands.

● **Annual growth of 10%**—Rep. Craig Hosmer (R.-Calif.), ranking House minority member on the Joint Committee on Atomic Energy, estimated that no less than 43 Congressional committees and subcommittees authorize or appropriate funds to be spent by more than 20 Government agencies on oceanographic programs. "This year the total sum is $135 million," he told the conference.

Hosmer noted the accelerated industry interest in oceanography now that the field is experiencing an annual growth rate in federal expenditure of 10 to 11%. He estimated that by 1972 the Government's oceanographic spending rate will reach $350 million annually, and total expenditures over the years 1962-72 will have been about $2.2 billion.

He said this money pays not only for studies and hardware for the Navy, which spends about 50% of the oceanographic budget, but also for work by agencies such as the Army Corps of Engineers, Weather Bureau, Coast and Geodetic Survey, Bureau of Sports Fisheries, Coast Guard, Bureau of Mines, National Science Foundation, Atomic Energy Commission, Fish and Wildlife Service and the Public Health Service.

Turning to industry's interest in the oceans, even beyond that of extracting minerals, food and fuel from them, Hosmer foresees some of the waters turned into valuable real estate. He observed there is "little likelihood that our coastline actually will ever be available . . . for our nuclear power and water desalting industry." Thus, the industry will have to go to sea.

In this connection, the Metropolitan Water District of Southern California has asked the Bechtel Corp. to study the possibility of creating a 40-acre offshore island, according to Hosmer. Several such islands for oil drilling are already in existence or are being built off the West Coast.

Hosmer proposed using nuclear reactors to supply the power needs of very large, stationary undersea terminals for mining, drilling and other purposes. He drew attention to one of the Project Plowshare studies indicating "a nuclear detonation can create a vast fractured cavern far beneath the sea's bottom in which great heat is captured." By introducing water into the fracture zone, the system could generate heat to drive a station's turbo-electric generators.

● **Navy proposal due**—Next month the Navy Special Projects Office expects to ask industry to bid on the development and construction of a deep-submergence rescue vehicle. This will be the first part of a four-element program comprising the Deep Submergence Systems Project (DSSP).

First prototype of this vessel is expected to cost in the neighborhood of $5 to $10 million and be afloat by December, 1968. This was the estimate of Samuel Feldman, head of the Deep Submergence Vehicle Program in the Special Projects Office. The prototype will weigh about 25 tons and will be followed by production models. By 1970, six rescue vessels are expected to be operational.

Although the vessels' primary mission will be rescue, "Ninety-nine per cent of their time will be taken by the secondary mission of oceanography," said Feldman.

The system will be designed to enable a rescue vessel to reach any point on 50% of the Earth's surface within 24 hours after a distress call is received, and to begin rescue operations. The vessel will be transported by a C-141 aircraft to an appropriate ocean port. Here, either a ship or submarine will take the vessel to the scene.

Feldman says his group prefers using a mother submarine, on which the rescue vessel would be "piggy-backed." He criticized the use of a surface ship because it would be subject to weather, citing as an example the high seas that thwarted initial attempts to send search and rescue ships over the site of the Thresher tragedy.

The rescue vessel would essentially be an "underwater helicopter, able to land on the distressed submarine, make a seal at its hatch, and get the personnel out," said Feldman. "This has never been done before."

● **Program outlined**—The rescue vessel would be developed to operate safely at the collapse depth of operational U.S. submarines. This is only the first element in the Navy's overall deep submergence program.

Other elements:

—Develop a manned system that will allow survey, investigation and recovery of small objects down to a depth of 20,000 ft. A search vessel able to reach 6,000 ft. will be made first, followed by four units able to reach 20,000 ft.

—Devise a system able to salvage large objects, including sunken ships, requiring a deadweight lift of up to 1,000 tons from continental shelf depths of approximately 600-800 ft.

—Provide man with the capability of living and working in the deep sea environment at ambient pressure rather than at normal atmospheric conditions.

● **National programs needed**—In his keynote speech, Dr. James H. Wakelin, Jr., general chairman of the conference, and former Assistant Secretary of the Navy (R&D), called for clarifying the role of the Federal Government in its work in oceanography.

He proposed establishing a national advisory commission on the ocean "to determine the requirements of our country for the use of the ocean and for ocean science exploration and engineering over the next 10 years." He suggested establishing the commission at the highest levels of Government by the President "to develop a program which will guide the implementation of his expressed policies." ■

THREE NEW MISSILES being developed jointly by Nord Aviation of France and Boelkow GmbH of West Germany were shown at the Paris show. LEFT: Hot vehicle- or helicopter-mounted anti-tank missile is to be operational in 1967. CENTER: Milan lightweight anti-tank missile, also due to be operational in '67, will be fired from shoulder or tripod. RIGHT: Roland ground-to-air field army weapon system, designed for fair-weather only, is expected to be ready for use sometime in 1968.

Europeans Show New Tactical Missiles

Exhibits at Le Bourget show scale of effort to win bigger share of market; Part I of two-part special M/R report on Paris Show

by Michael Getler

PARIS—U.S. manufacturers of tactical guided missile systems can expect stiffening competition both at home and abroad from a European armaments industry that is investing heavily in a wide range of second- and third- generation missiles.

The scope of the European effort was apparent at the 26th Annual International Salon of Aeronautics and Space, which closed here June 20.

Six new missile systems under development in Europe were displayed publicly for the first time. Two other new systems, not shown because of security classification but described in some detail to MISSILES AND ROCKETS, may also figure prominently in future Continental and U.S. sales for the Europeans.

Among the missiles making their public debuts were the British medium-range ship-to-air *Sea Dart*, produced by Hawker Siddeley Dynamics; the Swedish Saab-produced *305A* air-to-surface guided weapon system; three new missiles under development by a French-German industry team headed by Nord Aviation and Boelkow GmbH—the *Hot* and *Milan* anti-tank missiles and the *Roland* surface-to-air missile; and the land-based version of Britain's Short Bros.-produced ship-to-air missile *Seacat*, known as *Tigercat* in its ground-based form.

Very limited mention, and no physical display, was given to the French-British *AS-37/AJ168* air-to-surface system being developed by Hawker Siddeley Dynamics and Engins Matra, and to the British Aircraft Corp's *ET 316* surface-to-air weapon. However, both of these weapons system could figure prominently in future new business.

● **Sea Dart**—The Hawker Siddeley missile reflects considerable confidence in the ramjet-sustainer approach to effective fleet area defense against highly maneuverable high- and low-altitude aircraft in the 1970-80 time period.

The reduced-scale model shown at the Le Bourget display grounds (M/R, June 14, p. 21), while the first to be viewed publicly, is not believed to be a completely true reflection of the design scale. *Sea Dart*, under development since 1962, has reportedly been fired successfully in numerous trials. The missile is not yet operational, however, and no dates for deployment have been released.

The missile uses a fixed cruciform wing configuration and in-line control surfaces. It has a tandem-mounted solid propellant rocket booster, which also mounts stabilizing fins, to bring the missile quickly to ramjet operating speed. Use of the Bristol Siddeley Odin ramjet to sustain and control powered flight virtually throughout the flight regime is believed to enable *Sea Dart* to defend against maneuvering high-altitude aircraft at ranges in excess of 20 miles, and at ranges in excess of 10 miles for low-altitude craft. The system is believed to use a semi-active radar guidance system.

The British view *Sea Dart* as a U.S. *ASMS*-type of weapons system, more closely suited to handling the high-performance evasive-action type of air threat during the next decade than are boost-coast missiles, which the British believe quickly become range-limited against highly maneuverable targets in the coast phase.

In addition to proposals for *Sea Dart* as a sea-based weapon, HSD has, under company funds, developed the concept for a mobile, air transportable, land-based version of the missile, which it feels offers major size, weight, and performance advantages. The land-based version reportedly has attracted some NATO interest.

● **Saab 305A**—The Swedish Air Force will put its 11½-ft.-long, 660-lb. air-to-surface missile system into production this year, for use first aboard the Saab 105 jet attack aircraft and then with the new Saab 37 Viggen multi-purpose STOL aircraft.

The solid-motor, supersonic missile has been test-flown successfully and is designed primarily for low-level attack,

using visual guidance and a radio command link with the pilot. The Swedes report they will make a heavy push for foreign sales of the missile, possibly in conjunction with the 105, and may direct efforts toward non-NATO countries such as Australia.

Saab engineers also told M/R that an all-weather day/night version of the *305A* is also likely to be developed.

The missile in its current version carries a new Swedish-developed conventional warhead and is reported to contain highly sophisticated anti-jamming equipment. The *305A* uses two pair of sharply swept cruciform wings and four smaller control surfaces farther aft.

Saab engineers also report that air-to-air *Falcon* missiles, being turned out by the company under a licensing agreement with Hughes Aircraft in the U.S., are achieving a 90% hit probability in test firings.

● **Hot**—One of the three new missiles being developed jointly by Nord and Boelkow, the *Hot* vehicle- or helicopter-mounted anti-tank missile, is now in final development stage and is expected to reach operational status in 1967. It is viewed as a second-generation replacement for the *SS-11*, with wide export possibilities in Europe.

The missile range is from 240 to 13,000 ft. It travels at 630 mph, uses a solid motor, and weighs 44 lbs. at launch. *Hot* measures just under 4 ft. in length and is about 5 in. wide. The weapon with its tubular launcher-storage container weighs 55 lbs. The system uses a visual target tracking system for the operator and IR homing for the missile, with a wire command guidance system for corrections in flight.

● **Milan**—Also expected to be ready in 1967, the lightweight anti-tank *Milan* is aimed at the large replacement market for the French *Entac* and German *Cobra* missiles. This missile is similar in operation to the *Hot* in terms of guidance, but is designed to be handled as an infantry weapon fired from the shoulder or a tripod.

The missile travels at 400 mph, is reportedly effective at ranges of 240-6,500 ft., and weighs 22 lbs., including the 9-lb. launch tube. The *Milan* also includes an 11-lb. launch and control unit. The missile is 2 ft., 3 in. long and 3 in. wide.

● **Roland**—About one year behind *Hot* and *Milan* in terms of prospective operational status, the new *Roland* ground-to-air field army weapon system represents the most extensive endeavor in a new class of weapons for the Nord-Boelkow combination.

The missile is designed for interception of low-flying aircraft flying at speeds up to Mach 1.3. The missile is a fair-weather-only system being designed for deployment with small units.

Roland is said to be effective between a minimum target intercept range of 1,650 ft. and the maximum missile range of 3.2 nautical miles. The missile, about 8 ft. long, 6 in. wide, and weighing about 140 lbs., is launched from a 22-lb. plastic tube combination launcher, storage and transport container. An associated launching unit is mounted on a lightweight tracked vehicle.

This unit includes a search and surveillance radar, optical target sight, IR tracking system, and a computer for processing missile commands. The radar provides target azimuth data and the optical system provides elevation data. The target is tracked visually after missile launch and the missile is guided with a radio command system that positions jet vanes aboard *Roland*. The surveillance radar range is 8.1 miles, and *Roland* can reach a speed of Mach 2 at the end of the acceleration phase.

Missiles are stored within the vehicle and brought into position within the launch tubes by means of a hydraulic system. Each launch automatically initiates loading of the next round.

● **Tigercat**—Also shown at Le Bourget was the land-based version of the highly successful short-range ship-to-air *Seacat* missile produced by Short Brothers and Harland, Ltd. *Seacat*, adopted by the British Royal Navy, has been sold to seven other nations, and Short says it expects further orders for the missile.

The land-based *Tigercat* is exactly the same as *Seacat* except that it uses a three-missile launcher and director, each mounted on a two-wheel chassis.

The Royal Air Force has decided to purchase the *Tigercat* for airfield defense. Announcement of this order is expected shortly. It is the first production order for the *Tigercat*, but some additional foreign sales are anticipated. Until now, sale of this weapon abroad was hampered by the fact that the British government had not yet bought it.

The U.S. Navy has been participating in trials of the *Seacat as a* surface-to-surface weapon. The shots have been conducted off Pt. Mugu, Calif. (M/R, May 24, p. 9).

● **ET316**—Though not shown at Le Bourget because of a British security clamp, the relatively low-cost and simple *ET316* surface-to-air missile system, has already been presented to several European countries, both in and out of NATO, including the U.S. (M/R, June 14, p. 9), and insiders say export possibilities look promising.

The *ET316*, being developed by the British Aircraft Corp., is believed to be an outgrowth of a much more complex system, the *PT428*, which was started and then cancelled several years ago.

The missile is now in the hardware phase and has been successfully fired. It is believed to be a fair-weather-only system using a TV guidance system and visual target tracking. There is also the possibility of licensing agreements for this missile, according to industry sources.

BAC's *Thunderbird II* air defense weapons system is now engaged in combat with the U.S. *Hawk* regarding sales to Saudi Arabia. MISSILES AND ROCKETS first reported the offer of *Hawks* to the Saudi Arabian government.

● **AJ168/AS-37**—Interest in this joint British-French effort to develop a new air-to-surface missile system (M/R, June 14, p. 9) has also reportedly spread to other countries. The British version of the system is being designed with a TV guidance system, and the French version uses a radar guidance package. The systems will be interchangeable, according to sources here, and there also will be provision for other types of guidance techniques.

The missile range has been described as in tens of miles, and operational status is expected in 1968-69. The missile has reportedly undergone successful test firings. The U.K. version is being produced by Hawker Siddeley Dynamics and the French system by Engins Matra.

In a related area, Engins Matra also showed at Le Bourget the first models of its bomb retardation scheme, which involves a parachute deployment in combination with a sensing system which will prevent the bomb from exploding if any one of several aircraft safety-distance parameters is not met. The system was presented to U.S. officials last month. It can be used for 500-, 750- and 1,000-lb. bombs.

The French firm also showed the new rearward sonobuoy launcher for the Breguet "Atlantic" ASW craft in service with the French, West German and Netherlands navies. The system uses a powder charge for ejection, which is variable with aircraft speed in order to equalize the ejection speed aft with the forward speed of the aircraft. A new launcher able to hold 12 sonobuoys is expected to be introduced shortly.

Although it is not strictly a new missile, Sweden's *Saab 08*, an operational weapon system developed from the French *CT 20* jet-powered target missile, was publicized at the show. The Swedish Navy early this year placed a $16.5-million order for this missile, which also will be delivered to the coast artillery.

The French and Germans also displayed their current line of air-to-air, air-to-surface and anti-tank weapons. ■

(Next week, Part II of the Paris Air Show report will be devoted to space displays, dominated by the USSR.)

Pad Built Up for Titan III-C Shot

All mechanical assembly and mating to be conducted at ITL facility for next launch, due in September; details of future planning

CAPE KENNEDY—First scheduled launch of the *Titan III-C* involved a buildup of the vehicle on Pad 40 of the integrate-transfer-launch (ITL) facility in the conventional method used for all launches at the Cape to date. Not until the third planned launch of the huge new booster—tentatively expected sometime this November—will all of the ITL facilities come into play.

Air Force spokesmen report that although original scheduling of the first two launches of the full *Titan III* vehicle called for conventional on-pad buildups, progress in the program will now permit exercise of all the mechanical assembly and mating techniques, using ITL facilities, on the second launch, tentatively slated for September.

Present plans call for assembly of the second *Titan III-C* test vehicle to begin within the week following the first launch. The *Titan III-A* liquid-propellant core vehicle will be assembled in the Vertical Integration Building (VIB) and the 120-in.-dia. solid-propellant, five-segment strap-on motors in the Solid Motor Assembly Building (SMAB). All other elements of a fully integrated launch would be included, with the exception of the final mating of all electrical circuits and systems. The latter checkout will be conducted on the same pad (40) as in the first launch.

Depending on progress in the program by the September launch date, actual physical mating of electrical connections may also be attempted for the second launch.

Presumably, even the electronic checkout vans will make the trip to the pad with the assembled *Titan III-C* vehicle, in a full physical exercise of all ground handling equipment on the second launch. The third launch, with its full exercise of ITL facilities, will mark the first use of Pad 41.

Although tentative plans for test-flight payloads may still change many times before the end of the flight-test series, programmed for 12 *Titan III-C* vehicles, informed DOD sources said the second launch will now carry a payload, rather than the ballast originally planned for the first two shots.

● **Going aboard**—Tentative planned payloads for the remaining *Titan III-C* launches include: Launch 2—An *OV-2-1* satellite and an MIT radar calibration sphere (this combination being the heaviest payload ever launched by the U.S.); Launch 3—Two *LES* satellites and an *OV-2* satellite; Launches 4, 5 & 6—"A DOD communications satellite system" aboard each; Launch 7—NASA's refurbished *GT-2* capsule as an *MOL* heat shield qualification (HSQ) test; Launch 8—*Vela* nuclear detonation detection satellite system; Launch 9—Tentatively, two *LES* satellites and an *OV-2* satellite (alternatively, a *Vela* satellite backup); Launch 10—"A 3,900-lb. payload on a lunar or escape trajectory"—this could involve lunar impact, circumlunar impact or escape. Launches 11 and 12 are now tentatively reserved for tests involving early vehicles in the *MOL* program.

● **Launch sequence**—Some five seconds after liftoff, in a launch employing last week's flight plan, the vehicle will roll six degrees about its longitudinal axis to the launch azimuth of 160 deg. The roll maneuver lasts three seconds.

Ten seconds into the flight, the *Titan III-C* will pitch over into the arc of the trajectory. Some 108 seconds after solid motor ignition, the *Titan III* central-core stage-one engines will ignite. Ten seconds later, the burned-out 120-in.-dia. solid booster stages will be dropped away in a programmed manner. About 210 seconds after liftoff, the payload fairing will be jettisoned. Some 59 seconds later the second stage will have ignited and separated from the first stage. This stage will shut down 463 seconds into the flight, and 10 seconds later the stage will separate.

The Transtage, or stage three, will ignite 476 seconds into the flight, and at T plus 732 seconds the lead payload should be in a 100-mi.-high orbit. The Transtage engines will be shut down and no restart is planned for this mission.

As the Transtage orbits the Earth, the attitude of the guidance gyroscope platform remains constant, but the keel of the vehicle will always face the Earth. This in effect results in the Transtage revolving about the gyroscope platform. As the Transtage turns, wires connecting it with the guidance platform gradually twist and tighten.

The de-pitch reverses the turning motion and replaces the gyroscope and Transtage in their original relationship. Some four orbits later the Transtage will separate from the 21,000-lb. dummy payload; both will orbit three or four days before burning up during re-entry.

● **Acid test**—The crucial point in the first mission was burning time of the tandem 120-in. solid boosters. The central core already had flown successfully four times in its *Titan III-A* configuration. Ability of the 120-in. motors to come within fractions of a second of thrust of each other had been demonstrated in the repeated static-test firings. Stipulated thrust variation imposed on United Technology Center by the Air Force is one percent.

The current shot used a five-segment model of the solids, although seven segments are possible—and this would add considerably to overall thrust. There are also studies covering substitution of 156-in.-dia. solids for the current 120-in. version.

The UTC propellant is an advanced rubber-based polybutadiene acrylonitrile fuel with aluminum additives in the form of minute spherical powders, manufactured by Valley Metallurgical Co. Ammonium perchlorate is the oxidizer, and oxidizer fuel ratio is 70 to 30.

Specific impulse is about 248 seconds and the mass ratio is 0.88. Both boosters deliver peak thrust of over 2.4 million lbs.

The 23-mi.-altitude start of the Aerojet-General engines on the Martin *Titan III* core raises their ground-level thrust from 430,000 lbs. to about 474,000 lbs. The engines are protected from the heat generated by the two solids by a boattail arrangement, and the increased weight imposed by this means an increase of 70 slugs foot squared to the power level for initiating engine gimballing.

During its boost phase, the liquid core will experience some 2.9 g of loading and a maximum heat rise on any engine part of 200°F. In operation, the first liquid stage will accelerate from 3,600 mph to 9,643 mph, with g-loading in the 5-6-g range.

The $800-million *Titan III* (development) program is under executive management of Air Force Space Systems Div. and technical direction of Aerospace Corp. ■

California Aerospace Firms Again Lead Nation in Space Agency Dollars

NASA'S REPORT ON procurement actions in the first half of Fiscal Year 1965 revealed that 10 states accounted for 93% of the total, with California again leading with $1.2 billion of a primary contracts total of $2.3 billion.

Following were Louisiana with $270 million; New York, $218 million; Alabama, $100 million; Texas, $84 million; Missouri, $83 million; Florida, $64 million; New Jersey, $45 million; Maryland, $38 million, and the District of Columbia, $29 million.

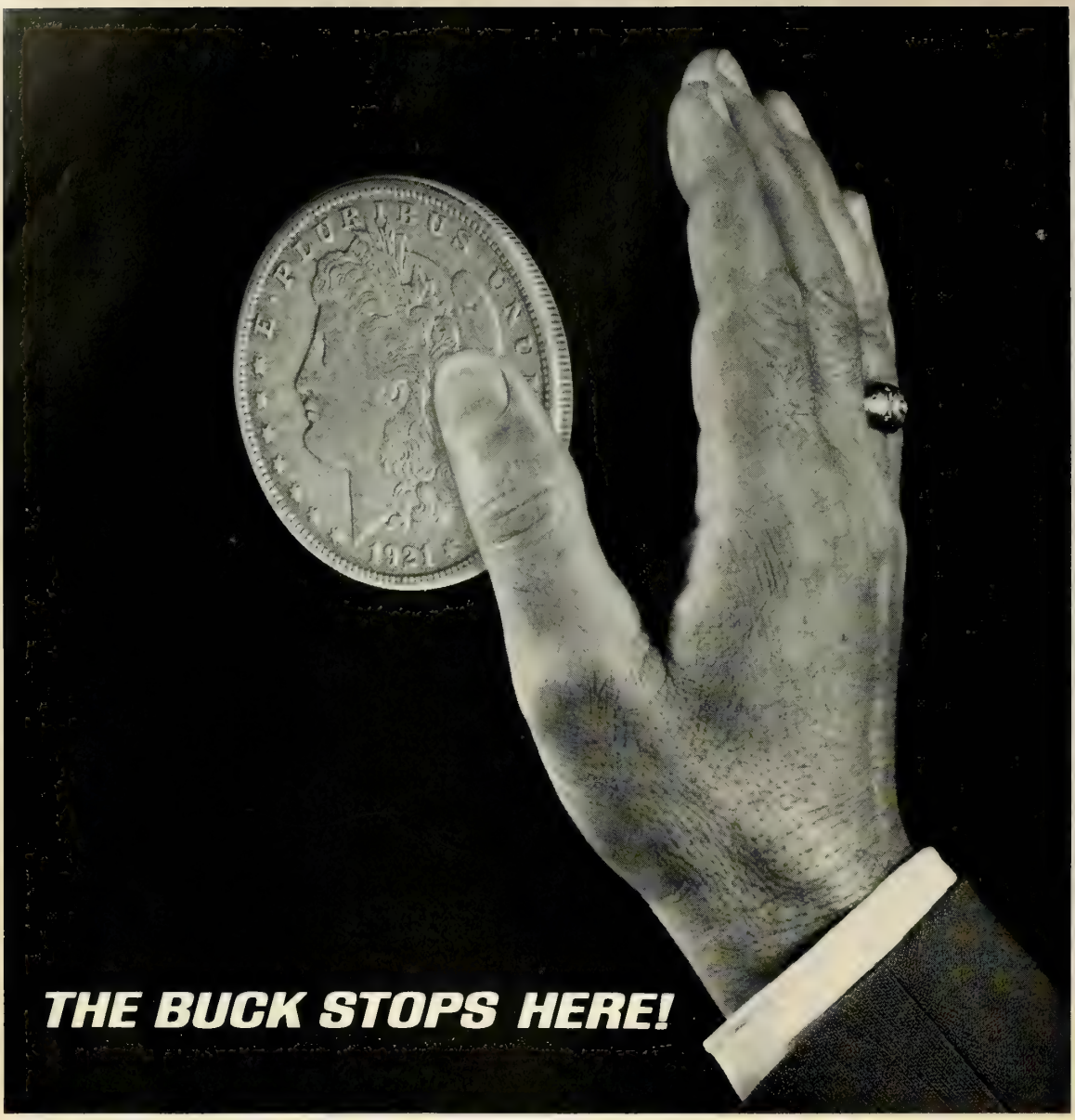
A breakdown of first- and second-tier subcontracts totalling $507 million also revealed that the same 10 states accounted for $344 million of the total. Values of subcontracts going to individual states were: California, $245.1 million; Louisiana, $11.2 million; New York, $23.7 million; Alabama, $15.8 million; Texas, $10.3 million; Missouri, $2.1 million; Florida, $17.5 million; New Jersey, $8.5 million; Maryland, $9.5 million; and the District of Columbia, $0.5 million.

• **51% lead over FY '64**—NASA's procurements for the period extending from July 1 to Dec. 31, 1964, totalled about $2.928 billion. This is $989 million, or 51% higher than procurements in the same period of FY 1964. Of the total, awards to business amounted to $2.386 billion; educational institutions, $37.6 million; non-profit organizations, $5.7 million; Jet Propulsion Laboratory, $128.8 million, and other Government agencies, $366.1 million. About $3.7 million went to areas outside the United States.

Use of competitive contract procedures increased during the first six months of FY '65 compared to the first six months of the prior fiscal period. Of the total awarded to business, 68% involved competitive negotiating compared to only 57% in the first six months of FY '64. Cost-plus-fixed-fee contracts accounted for 80% of the awards to business, 6% were cost-plus incentives, and 10% were firm-fixed-price contracts. Of the cost-plus-fixed-fee contracts, 94% of the contracts awarded involved fees ranging from 7 to 8%.

In the awards to business, 95% went to large business firms and 5% to small business firms. ■

CONTRACTOR	RANK JUL-DEC 1963	NET VALUE OF AWARDS	
		THOUSANDS OF DOLLARS	PERCENT OF TOTAL AWARDS TO BUSINESS
TOTAL AWARDS TO BUSINESS		$2,386,032	100.00
1 North American Aviation, Inc.	1	796,825	33.39
2 Boeing Co.	5	233,096	9.77
3 Grumman Aircraft Engineering Corp.	6	172,246	7.22
4 Douglas Aircraft Co., Inc.	3	138,285	5.79
5 Aerojet-General Corp.	8	101,804	4.27
6 General Electric Co.	9	87,633	3.67
7 McDonnell Aircraft Corp.	2	82,318	3.45
8 International Business Machines Corp.	10	57,987	2.43
9 General Dynamics Corp.	4	56,953	2.39
10 Chrysler Corp.	7	56,876	2.38
11 Radio Corporation of America	11	46,359	1.94
12 Bendix Corp.	14	36,672	1.54
13 Thompson Ramo Wooldridge, Inc.	16	28,161	1.18
14 United Aircraft Corp.	13	23,120	.97
15 Collins Radio Co.	34	22,577	.95
16 Hayes International Corp.	17	21,984	.92
17 Hughes Aircraft Co.	31	19,208	.80
18 General Motors Corp.	15	18,940	.79
19 Brown Engineering Co.	12	14,886	.62
20 Philco Corp.	23	14,539	.61
21 Lockheed Aircraft Corp.	18	13,647	.57
22 Catalytic Construction Co.	—	11,639	.49
23 Bellcom, Inc.	21	9,804	.41
24 Sperry Rand Corp.	36	8,035	.34
25 Lear Siegler, Inc.	60	6,931	.29
26 Mason-Rust	28	6,927	.29
27 Fairchild Hiller Corp.	30	6,880	.29
28 Trans World Airlines	—	6,755	.28
29 Honeywell, Inc.	53	6,443	.27
30 Ling-Temco-Vought, Inc.	27	6,075	.25
31 Westinghouse Electric Corp.	58	5,876	.24
32 Control Data Corp.	45	5,377	.23
33 Union Carbide Corp.	29	5,131	.22
34 Republic Aviation Corp.	38	5,047	.21
35 Zia Company	67	3,852	.16
36 Graham Engineering Co.	77	3,594	.15
37 Motorola, Inc.	75	3,427	.14
38 American Telephone & Telegraph Co.	32	3,384	.14
39 MSI Corp.	—	3,380	.14
40 Pennsalt Chemicals Corp.	—	3,332	.14
41 Garrett Corp., The	62	2,972	.12
42 Spaco, Inc.	37	2,927	.12
43 Kiewit/Leavell Jt. Vt.	—	2,815	.12
44 Avco Corp.	43	2,740	.11
45 Ampex Corp.	74	2,638	.11
46 Northrop Corp.	42	2,633	.11
47 Allis Chalmers Manufacturing Co.	—	2,576	.11
48 Reeves Instrument Co.	—	2,483	.10
49 Sun Shipbuilding Dry Dock Co.	—	2,384	.10
50 Martin Marietta Corp.	39	2,290	.10



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Technical Countdown

RESEARCH AND DEVELOPMENT

Air Force R&T Scope Outlined

Maj. Gen. M. C. Demler, commander of the Research and Technology Division of Air Force Systems Command has cited the total RTD activities budget as running about $500 million annually. Present capital investment in plants and equipment amounts to almost the same figure. In addition, Gen. Demler told the Air Force Materials Symposium in Miami recently that the R&T Div. has in being, at present, approximately 300 active projects with more than 6,500 open R&D contracts for a total value of $1.6 billion. Covering the business aspects, Gen. Demler told industry representatives at the gathering that his headquarters is no place to sell new technology—industry should go directly to the responsible lab for a quick evaluation. Each lab director has been provided with funds to initiate promising research and development without prior approval or review.

MATERIALS

Wind Tunnels May Simulate Nuclear Blast

Counterflow wind tunnel techniques are being investigated in a Defense Atomic Support Agency program to develop a method to simulate the effects of nuclear weapon detonation on re-entry vehicles. The aim of this and other methods being studied is to investigate the interaction of the re-entry body bow shock wave with the spherical shock wave from a nuclear explosion and ultimately, the effects to the vehicle. In the counterflow technique, a body is fired upstream in a shock tube. An approach that showed some potential and has been shown feasible in part, is use of a line charge of high explosives to simulate the bow shock, since such detonation velocities are about the same as those of vehicles re-entering the atmosphere from high trajectory launches. This latter approach is not currently being pursued.

Martin's FLAME Facility Open to Industry

Advanced materials for nose caps, nose cones, leading edges and other high-temperature environment applications can be tested under contract to Martin Orlando in its FLAME facility. FLAME generates burning rocket gases at chamber pressures of 5,000 psia and temperatures over 5,000° F—directing the exhaust at materials samples suspended in a test fixture. Sting-mounted specimens such as nose cones with attached vanes and antenna windows can be completely instrumented and exposed for up to 15 seconds in the exhaust of the boilerplate solid-rocket gas generator. FLAME and the subscale test facility are now available for both commercial and military customers. (M/R, Aug. 24, p. 35).

House Graup Okays AF Materials Facility

The House Armed Services Committee has agreed in conference to include $6.7 million in the FY '66 program for a new materials laboratory at Wright-Patterson AFB. In announcing the move, Rep. Joseph E. Karth (D.-Minn.) told the 1965 Air Force Materials Symposium in Miami Beach that unless it hits a snag in the Appropriations Committee, this facility should soon become a reality. Karth is third-ranking Democrat on the House Science and Astronautics Committee. Earlier, Gen. B. A. Schriever, commander, AFSC, told the group that the technological advances needed for new aircraft have been identified. In covering the technology, Schriever mentioned a long-range, long endurance aircraft. . . "which could perform a variety of military roles. These might include a strategic missile carrier which could patrol the air over international waters; a command and control center serving as an airborne command post during times of tension; a reconnaissance aircraft utilizing the most up-to-date techniques in intelligence gathering and a function such as acting as a standoff launcher of tactical missiles."

O_2 Generated from Lunar Rock Types

A team of Aerojet-General Corp. scientists say they have produced oxygen from three types of rocks they theorize will be present on the lunar surface. The rocks are melted in a special furnace, chemically reduced to produce water, which is then electrolyzed to yield oxygen and hydrogen. The oxygen is then liquified for a propellant. Aerojet has produced small amounts to demonstrate feasibility under a NASA research contract.

PROPULSION

LEM Rocket Chambers in Production

Titanium engine chambers and chamber shells for the descent rocket engine of the Lunar Excursion Module are in production at Ryan Aeronautical Co. The order from TRW Space Technology Labs totals approximately $800,000 and the production phase will run into 1966. The engine itself will be trottleable over a thrust range from 1,000 to 10,000 lbs. and is required to burn continuously from a lunar altitude of 50,000 ft. to within a few feet of the lunar surface.

SPACE MEDICINE

Self-powered Sensors Investigated

General Electric's Space Sciences Laboratory has been demonstrating the feasibility of using the bioelectric potentials of live animals to power internally implanted biosensors, giving such information as heart rate, temperature and other parameters. In one experiment, two dogs were tested for a total of 62 days, with regular measurements made on 37 days. Fibrous coating which occurred around the electrodes—the usual reaction of the body to foreign implantations—did not greatly retard the production of electric power. High-speed steel and platinum/platinum-black were found to be the best materials for electrodes.

Hypoxia vs. Deconditioning Studied

The Air Force's School of Aerospace Medicine is testing four subjects in its space cabin simulator to determine whether hypoxia—a condition in which the oxygen level in the atmosphere and body is lowered—can be used to prevent some aspects of deconditioning. Preliminary studies indicated that a 12,000-ft. altitude guards against calcium mobilization or loss of calcium through the urine, and prevents decrease in number of red blood cells. Four subjects will lie on their backs in the chamber for one month, eating normally, to see if simulated altitude will lessen symptoms of physical inactivity or bed rest.

Unique Low-Noise Antenna Developed

Distinctive horn design, incorporating yoke mount, also yields high gain; intended for communications satellite use

by Charles D. LaFond

A UNIQUE, rugged antenna for ground use in satellite communication links has been developed that employs a paraboloidal reflector segment and a hyperboloidal sub-reflector in a Cassegrain (folded) configuration. The feed is contained within the paraboloidal surface.

Under development for the past four years by Keltec Industries, Inc., (formerly Aero Geo Astro Corp.) in its Antenna and Microwave Div., Alexandria, Va., the KSK antenna provides both high gain and a very low noise figure. It was developed specifically to meet the overall needs demanded by state-of-the-art low-noise receivers, the firm says.

Original design for the odd-looking horn came from Ken Kelleher, Keltec's president, who disclosed that even he had difficulty convincing his technical staff of the advantages of such a system. With fabrication and successful testing of the first antenna, Kelleher said, all doubts were removed—at least within his own organization.

Previously, with receiver noise temperatures on the order of 1,000°K, the contribution to system noise temperature of the conventional paraboloid with focal-point feed was not significant. Recently, however, cryogenically cooled receivers have produced receiver noise temperatures of 10°K and uncooled parametric amplifiers have been reported with noise temperature below 100°K.

The antenna noise picked up with such receivers is significant and effort was concentrated on its reduction. This noise at the satellite communications frequency of 5 to 10 gc results primarily from illumination of the Earth by side lobes and back lobe of the antenna.

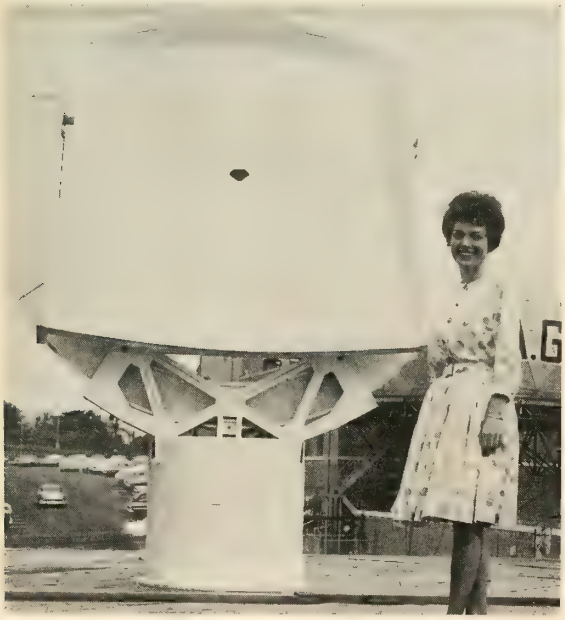
● **Folded structure**—The proprietary antenna design (patents are now pending) was developed to meet these requirements. It evolved, say Keltec officials, from the excellent results obtained by Bell Telephone Laboratories with the horn reflector structure used in the *Telstar* communications link. But, Keltec points out, the BTL structure is very large and unwieldy.

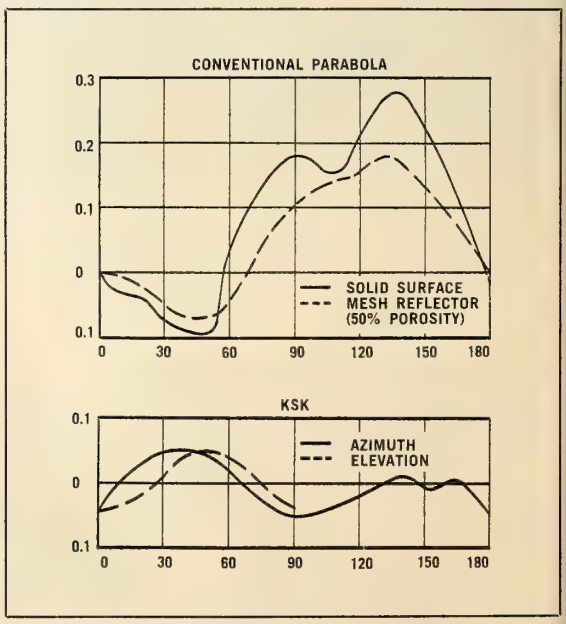
The KSK antenna replaces the horn with a virtual source created by use of a hyperbolic reflector in the same way the Cassegrain reflector is used with a parabolic dish. The feed then is located in the surface of the parabolic reflector, which affords very good accessibility.

Several versions of this antenna have been built and tested, including a 25-ft.-aperture model having automatic track capabilities. Measured far side lobes and back lobes for the antenna are more than 65 db below the beam maximum and approximately 20 db below the isotropic level, developers claim. The focal-point-feed paraboloid has a corresponding level of only about 4 db below isotropic.

Excess noise contribution for the

LEFT: KSK antenna employs unique Cassegrain design for low-noise ground use with communications satellites. RIGHT: Comparative moment coefficients for the KSK versus a conventional dish antenna.





KSK antenna, developers disclose, is less than 5°K even for low aspect angles as compared with a figure of 60°K for the focal-point-feed parabola or 30° to 40°K for the parabolic antenna with Cassegrain feed system. The KSK, according to Keltec, provides a system noise temperature lower by approximately 3 db when used with a receiver with noise temperature of 20°K.

• **Low-angle track**—The KSK low side lobes also result in improved tracking capability at low elevation angles because ground clutter is reduced. In a recent test by Page Communications Engineers, a division of Northrop Corp., the antenna was used to track the *Relay* satellite from the horizon to 3 degrees above and back to horizon. This aspect angle was the maximum available for this orbit of the satellite. Pattern and gain measurements indicated an aperture efficiency of 70%. (A typical 360-degree pattern is shown.)

The mechanical advantages of the KSK antenna are an additional bonus, the firm asserts. It is inherently rigid because of its box-like structure and is logically supported by a yoke assembly for use with a tracking drive. As can be seen in the accompanying photo, the center of gravity of the antenna is located directly over the center of rotation, eliminating the need for counterweights.

The total weight and inertia of the KSK antenna are therefore substantially less than those of the conventional parabolic tracking system.

The center of pressure from wind forces is in line with the elevation and azimuth axis, reducing the wind torques and drive requirements to only a fraction of the same forces required for the typical parabolic antenna, Keltec designers say.

• **Transportability stressed**—Because the reflector is formed of aluminum honeycomb flat panels and panels having only slight curvature, surface accuracy and packing density are high, resulting in exceptionally easy erection and transportability. When erected, the antenna is inherently self-jigging so that no field alignment is required. Total weight of a KSK comparable to a 30-ft.-dia. dish is in the 2,500 to 3,000-lb. range.

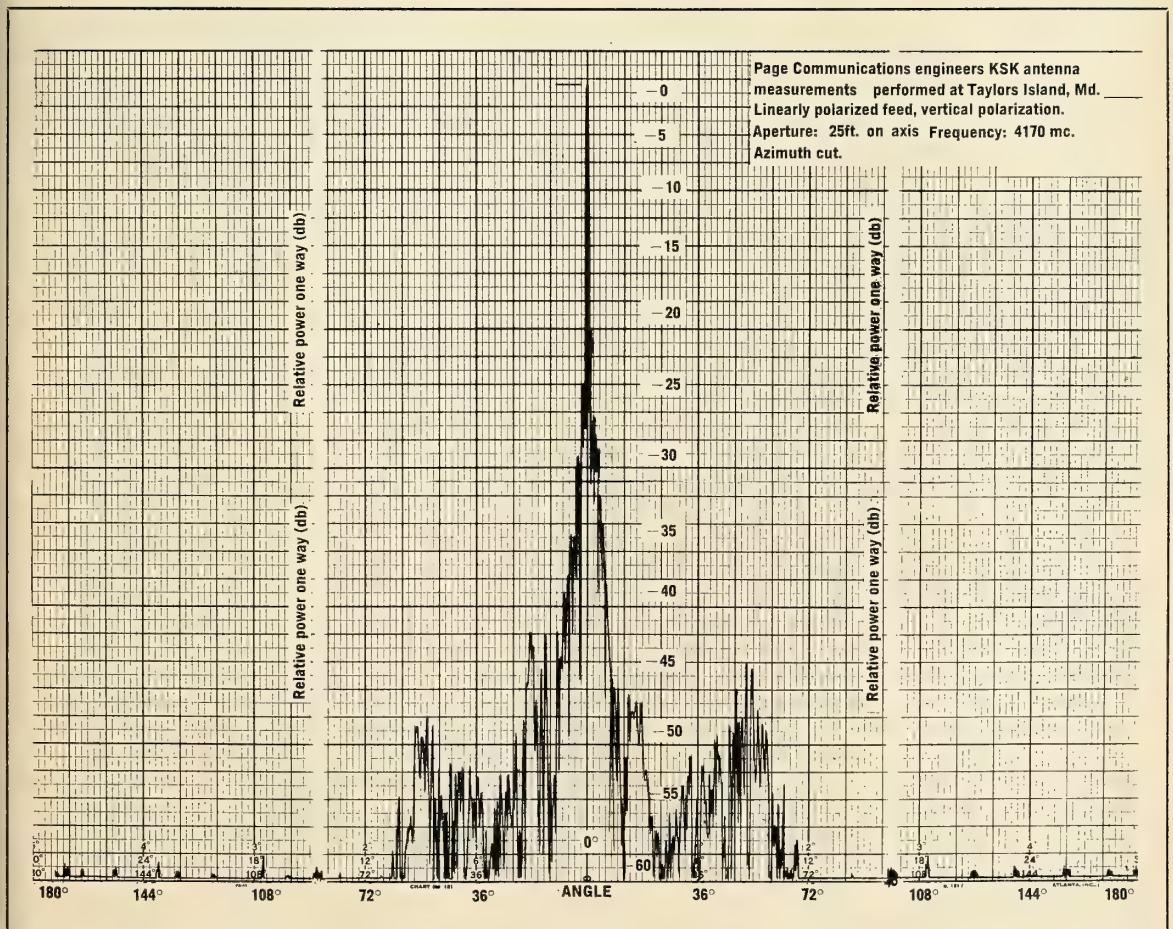
Noise temperature tests were recently completed on a 6-ft. KSK antenna by Associated Universities at Green Back, W. Va., Observatory. Measurements made on a variable overcast day showed a total temperature range from 2° to 8°K.

Kelleher says horns equivalent to dishes of up to 85-ft. in diameter will be built by his firm. Performance characteristics, he says, improve with size.

The first Keltec KSK antenna purchased went to Page Communications Engineers. Page plans to include it (renamed the Casshorn) in its proposed low-cost communications satellite ground terminal. The particular 25-ft.-long horn used is comparable to a 38-ft.-dia. paraboloidal reflector in performance, according to Page.

Both the Army, at Ft. Monmouth, N.J., and the Navy are reportedly considering buying KSK's for military communications satellite applications. ■

Pattern of 25-ft., 4170-mc KSK antenna.



NASA Intensifies Radiation Studies

First of three AIL-developed radio telescopes to begin task of identifying, measuring magnitude of solar bursts

by David A. Anderton

DEER PARK, N.Y.—The first of three radio telescope systems planned to study solar bursts that produce damaging radiation is in shakedown tests here at Airborne Instruments Laboratory, a division of Cutler-Hammer.

It is scheduled to start observations at the *Apollo* Integrated Mission Control Center, Houston, for the National Aeronautics and Space Administration in September.

Under a $330,000, 19-month Manned Spacecraft Center contract, two other systems will be delivered to sites in the Canary Islands and Carnarvon, Australia, for operational use by November, 1965, and February, 1966, respectively.

The three AIL-designed and developed radio telescopes will be operated in conjunction with seven globally-dispersed optical telescopes—three installed at the AIL equipment sites and the other four at widely separated points to circumvent Earth cloud-cover problems. Optical telescopes are being supplied by Razdow Laboratories, Inc., Newark, N.J. The system will be used for constant solar observation.

● **Dual mission**—The problem the telescope network is required to solve is a twofold one: first, it must identify, with high reliability, Type IV solar occurrences (see box); second, it must measure the magnitude of the event.

Originally conceived as part of the *Apollo* space radiation warning system, a proposed network that is still in a state of flux, the radio telescopes will be in operation long enough before any actual *Apollo* missions to furnish useful data on which to base predictions of solar activity and intensity. Still unresolved is whether or not these units become part of a direct warning system with hard-line communication to Houston.

Because of the difference in speed of radio-frequency propagation and the velocity of the high-energy protons that follow the Type IV event, it is possible to get the signal of the occurrence from one to four hours ahead of the time the protons reach the top of the atmosphere or the surface of the Moon.

It should be possible to give warnings of dangerous events in ample time for emergency action to be taken. The trick is first, to recognize the Type IV event; second, to determine its magnitude; and third, to estimate the danger from the accompanying energetic particles.

Current predictions of solar activity are based on the statistics of past years of observations. They can show with some confidence that X or Y solar events will happen within the next Z days. But that information is of limited usefulness to astronauts. What NASA needs to know is the probability of the occurrence of a solar event, its magnitude with respect to some established safety limit, and the approximate time of its occurrence. That kind of informations, so far, can come only from long-term statistical data of the sort that will be gathered by the AIL radio telescopes.

● **Receiver description**—The heart of the radio telescope system is the receiver, a three-channel radiometer operating in three microwave frequency bands: 1,400-1,427 mc; 2,690-2,700 mc; and 4,990-5,000 mc. These bands have been cleared specifically for radio astronomy.

Choice of the frequencies, which

Five Kinds of Radio Frequency Radiation Identified

THE RADIO FREQUENCY radiation of interest here is the type that is clearly identifiable—after the event. Five different kinds of RF activity have been identified and classified:

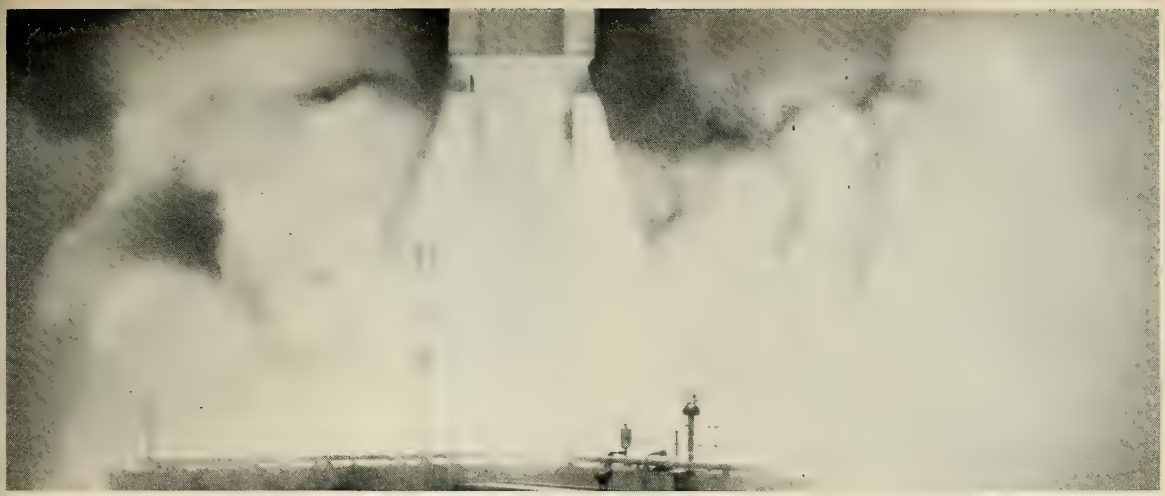
Type I: These are random noise storms that occur, and have no particular identifiable spectral characteristics.

Type II: These are slow-moving bursts of radiation from the Sun's surface that move up and out through the plasma around the Sun. Plotted on a curve of frequency against time—one of the typical readouts of a radio telescope system—the Type II disturbance resembles a plume of frequency changing with time as it moves out from the surface.

Type III: These are brief, intense bursts that show a rapid change in frequency in a very short time, and so appear as short vertical lines on a plot of frequency against time. These kinds of disturbances generally precede a Type II burst.

Type IV: These bursts usually are found following a Type II. They are recognized by their pattern; that is, they wipe through an area on the frequency-time plot. High-energy protons, moving at less than the speed of light, accompany this type of disturbance. They penetrate into the Earth's atmosphere, and trigger aurorae and cosmic-ray events. These are the energetic particles that are dangerous to humans. They can be dangerous to an astronaut outside the atmosphere. There is a definite correlation between the magnitude of a Type IV event and the energy of the protons that follow it.

Type V: This recently identified disturbance, whose characteristics are less easily defined is also a burst, and appears to accompany a Type III disturbance in the manner that a Type IV burst follows a Type II occurrence.



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solid propellant systems engineers

Conduct solid propellant rocket motor preliminary design and subsystems performance analysis. Analyze rocket motor interior ballistics and perform motor optimization trade-off studies. Knowledge of grain design-structural analysis interfaces and ramifications is desirable. BS or MS with four years minimum experience, including active ability to develop and handle coded motor design and optimization programs. Will also assist in proposals for major missiles and space systems programs.

storeable liquid propellant engineers

Conduct storeable liquid propellant rocket propulsion subsystems preliminary design and performance analysis. Knowledge of both pressure-fed and pump-fed rocket engine technology is desired, including throttling techniques, feed system dynamics, and engine heat transfer analytical techniques. Assist in proposals for major missiles and space systems programs. BS or MS with four years minimum experience including active ability to develop coded motor optimization programs.

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Conduct analytical and applied research in propulsion subsystem areas such as propellant tank hydrodynamics and boiling heat transfer in zero-g and low-g environments, expulsion and venting in zero-g. In addition, conduct applied research in cryogenic propellant feed system dynamics as well as in cryogenic propellant behavior in long term space storage environment. MS or PhD in M.E. or Physics with five years minimum experience including active ability to develop coded analytical programs.

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Conduct analytical and applied research in propulsion subsystem chemical kinetics, including non-equilibrium flow for solid storeable and cryogenic liquid propellant subsystems. MS or PhD in M.E. or Physics, plus five years experience including ability to develop coded analytical programs.

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span a relatively large portion of the spectrum where the Sun shows radio activity, was made to provide positive identification. For example, no Type II or Type III events have been observed in these ranges. It is possible that some noise or spurious signals could be heard on one of these bands. But the simultaneous reception of a signal on all three bands can only point to a Type IV event.

The basic problem in radiometer design is to distinguish very small changes in input, amounting to detecting noise in noise. These input changes are well below the background noise and receiver noise levels. A typical signal/noise ratio for a radiometer is on the order of 1/100. For comparison, only the most expert radar operator can detect a radar signal equal in magnitude to the noise. The radiometer beats that performance by two orders of magnitude, AIL claims.

Specifically, the AIL radiometer is required to detect changes of two percent of the quiet Sun. This corresponds to detecting a signal equivalent to 5°K. The basic parameters of the radiometer AIL developed for the job show that it will have a signal-equal-to-noise value of about 1°K, considerably better than required by the specifications.

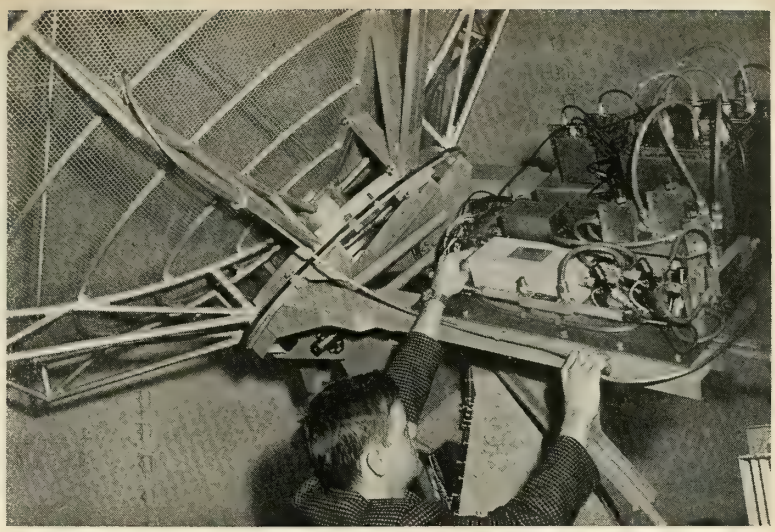
The radiometer is fed data collected by an eight-foot-diameter paraboloidal reflector antenna, which in turn is fed by a wide-band log-periodic feed at its prime focus. The equatorial mount designed for the antenna has its geometry fixed for 30-degree latitude. Its polar axis angle can be adjusted at the site by shimming. The entire antenna and its drive system and mount was developed and built by Jasik Laboratories, Inc., of Westbury, Long Island, N.Y.

● **Construction**—The antenna and its mount, plus the front end of the radio receiver equipment, is housed in an 18-foot-diameter glass fiber radome. The dome is insulated and air-conditioned for two major reasons: to maintain stability of the operating unit and to provide comfort for technicians if they have to work on any part of the unit.

The antenna control system includes a preset mechanism to adjust the start time of the unit for each day's operation. This could have been done automatically, but it would have been costly and complex.

During the operating day, the antenna tracks the Sun, following it from horizon to horizon. It then shuts down automatically and slews back to another preset position for the start of the next day's tracking.

Each radiometer channel produces both analog and digital readout. The analog data is traced by pens on a dual-channel strip-chart recorder for each band. One channel is sensitive, for small temperature change readings. The other covers the entire range of expected solar burst activity using a logarithmic response.



RADIO telescope developed for NASA by AIL is housed within an 18-ft.-dia. radome.

Analog-to-digital conversion stores the output voltage on magnetic tape.

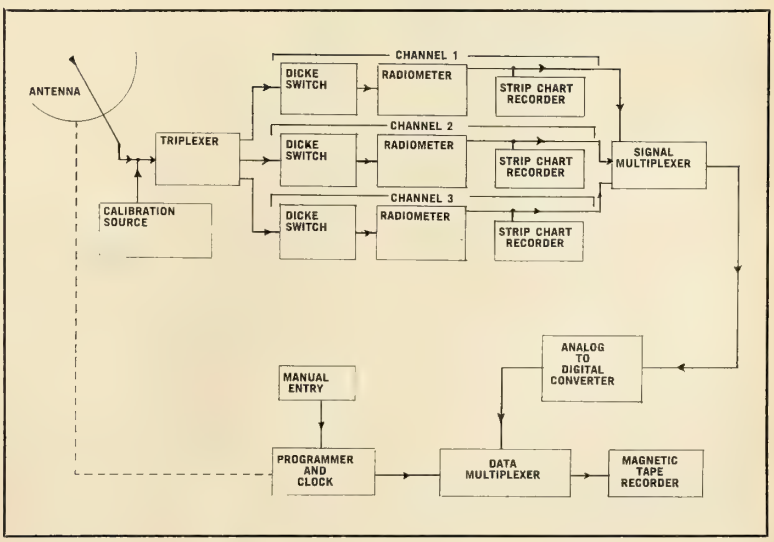
● **Spinoff anticipated**—AIL specialists will admit to being receiver experts, but they do not claim to be astronomers. Consequently they sought the advice of consultant astronomers Alan Maxwell, head of the Harvard Radio Observatory at Ft. Davis, Tex., and Arthur E. Covington, of the Canadian National Research Council.

As one result of that collaboration, the output data has been planned to be useful to the scientific community in addition to satisfying the mission-oriented requirements. For example, the sensitivity of the radiometer was increased somewhat to meet scientific needs. All records will be made available to radio astronomers working in the field of solar astronomy.

For the first time in astronomical history, the Sun will be observed and monitored on a continuous basis. There is feeling among some observers that the entire project could be justified on that basis alone.

But the main objective is to guarantee the safety of the *Apollo* crewmen when they are outside the protection of the Command and Service Modules, either in the Lunar Excursion Module or exploring on the surface of the Moon. ■

SIMPLIFIED block diagram of solar radio telescope.



UK-3 To Probe Lightning's RF Noise

British firm's experiment will be first satellite attempt to measure such energy continuously on a global basis

SLOUGH, ENGLAND—An attempt at using satellite-mounted instruments to measure radio-frequency noise generated in the Earth's atmosphere during lightning storms may produce data of considerable practical value—as well as purely scientific information in a long-neglected field of study.

An experimental package to gather these measurements is being developed for the *UK-3* satellite. The unit is being fabricated by Pye, Ltd., Cambridge, England, under contract to the U.K.'s Radio & Space Research Station here.

The Research Station's experiment is only one of five planned for the satellite, but it is unique in that it represents the first attempt at using satellites to make continuous noise measurements of this variety on a global scale. British scientists here say that knowledge concerning the number and location of lightning discharges, which create large amounts of RF energy, is still very meager and based to a large extent upon studies made in 1925.

Scientists are anxious to up-date both the earlier studies and more recent local measurements made by about a score of different fixed-location reporting sites on the ground. Furthermore, the data should be of value to communications systems designers in areas where RF traffic is often plagued by severe atmospheric noise.

Scientists here feel that successful data return could allow alterations in long-range communications signal strengths or frequencies to compensate for more certain noise ratios, and possibly to improve communications scheduling, receiver orientation, and antenna design. The data is also expected to be of interest to power-line engineers.

Looking further ahead, it is felt the data will also be useful at higher frequencies in extrapolated form to improve satellite communications net design with regard to noise attenuation. Scientists here feel that of the various forms of atmospheric noise and galactic noise which must be considered in space communications system design, the atmospheric noise is probably the greatest component. The U.S. military may also be interested in the experiment.

The *UK-3* is now slated to be placed into a 550-km orbit early in 1967 by a *Scout* launch vehicle. The launching will be from the Western Test Range and will place the 200-lb. satellite into an orbit inclined 78 degrees.

UK-3 is actually the first satellite of that series to be built in Britain. The first two, launched successfully in 1962 and 1964, were both built in the U.S. and carried British-built instrumentation and experiments.

● **Experiments**—The Research Station experiment will make separate measurements in the HF region immediately surrounding three major carrier frequencies—5, 10, and 15 mc.

Six separate narrow-band heterodyne receivers will be used, one on each side of each of the three major carrier bands to be monitored. The receivers will operate in the guard-bands adjacent to the center frequencies, an area which designers hope is "quiet." The center of each receiver band will be offset from the major carrier frequencies by about 2-kc. Use of receivers on either side of each band will allow experimenters to discriminate between RF interference from ground broadcasting and lightning-generated noise. Broadcast interference should normally appear as different signals in both receivers, with storm-generated noise providing roughly equivalent outputs from the receivers. Each receiver has a bandwidth of about 800 cps.

The original experiment design called for 10 mc as the highest frequency; however, as the launch date of the satellite slipped closer to 1967—a year of maximum sunspot activity—the frequency was increased to compensate for higher expected electron densities in the ionosphere.

Actually, the planning for *UK-3*, which carries electron ionospheric experiments, was aimed at having the satellite in orbit for a full year under these maximum solar conditions—the first time that a satellite of this type will be in that position.

● **Using ionosphere**—*UK-3's* orbit will place it above the maximum ionospheric electron density layer which will, in effect, allow the satellite's receivers to use the ionosphere to focus the incoming noise energy signals to provide better ground resolution and positional accuracy on any lightning discharge. Signals arriving from beyond an optimum cone angle should theoretically be bent back towards the Earth and not reach the satellite. Scientists here say that an optimum compromise between receiver accuracy and resolution might be provided by a ±20-degree reception cone covering about a 500-km-diameter viewing area on the ground. The satellite will be able to complete a global atmospheric noise measurement survey in about 60 days.

Discharge position information will be calculated based upon satellite orbital position data and ionospheric state data reported by ground stations around the globe.

The Research Station package, which measures 9 x 6¾ x 4-in. and uses 382 milliwatts of power, will make two basic measurements during continuous 25-second intervals—a count of the actual number of bursts and an average of the recorded RF envelope.

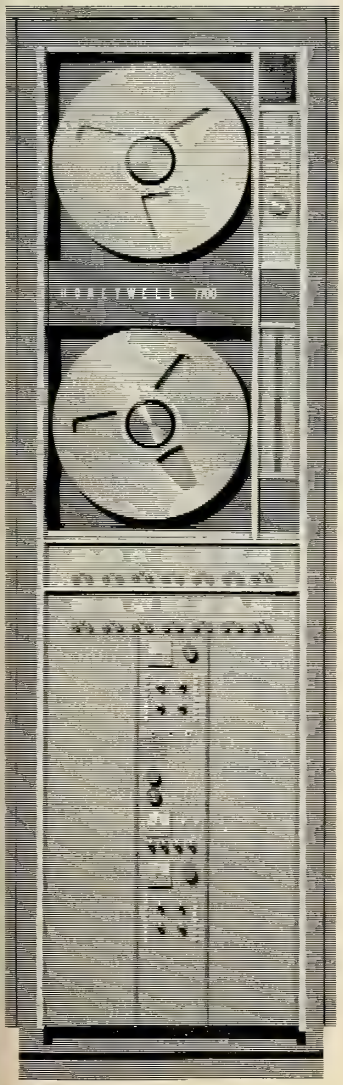
UK-4 In the Works?

AMONG THE BRITISH space programs now "under review" by the Government's newly created Space Research Council is a proposal for a fourth satellite in the *UK*, or *Ariel*, series.

The line of British experimenters anxious to find payload space is long, but the Government pocketbook nowadays is short, and no quick decision is expected. The *UK-4* proposal is one of several, many planned prior to the switch in British Government last fall, which have reverted to review status.

The Honeywell 7700 introduces these four significant advances in analog magnetic tape instrumentation:

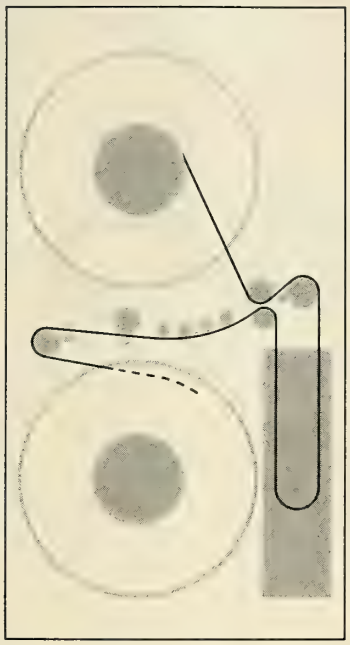
TIME DISPLACEMENT ERROR—Timing errors between record and playback can originate in dimensional changes in the tape caused by temperature, humidity and tension variations as well as differences in tape speed between record and playback. These effects have been minimized through use of a tape-controlled servo on the playback mode. Until now, however, high inertia systems could only reduce instantaneous timing errors to about 1 millisecond. The new Honeywell 7700 low inertia, high-response servo reduces this error to 1 *microsecond* at 120 inches per second.



FLUTTER—In the past, flutter has been reduced by use of high inertia drive systems which lose their effectiveness at low frequencies and low speeds. The high-response servo in the Honeywell 7700 virtually eliminates flutter below 100 cps and holds wideband flutter below 0.25% from DC to 10KC at 60 ips.

DYNAMIC SKEW—If data on two or more channels are to be compared, it is essential that varying time differences between channels caused by dynamic skewing of the tape be reduced. The use of vacuum column isolation and a 13-inch edge guide ahead of the record-playback heads reduces dynamic skew in the Honeywell 7700 to approximately one-third of that in state-of-the art analog systems.

SIGNAL/NOISE RATIO—Noise caused by electronics, tape and the tape transport can mask small amplitude data changes. Efforts to improve linearity, drift and other parameters are fruitless if a high percentage of noise is present. The



Honeywell 7700 will produce signal-to-noise ratios as great as 48 to 52 db rms. This is a 2-to-1 improvement over the 40 to 44 db noise found in other FM systems.

The Honeywell 7700 is an 80 KC FM-640 KC Direct system built specifically to preserve the quality of your most critical data.

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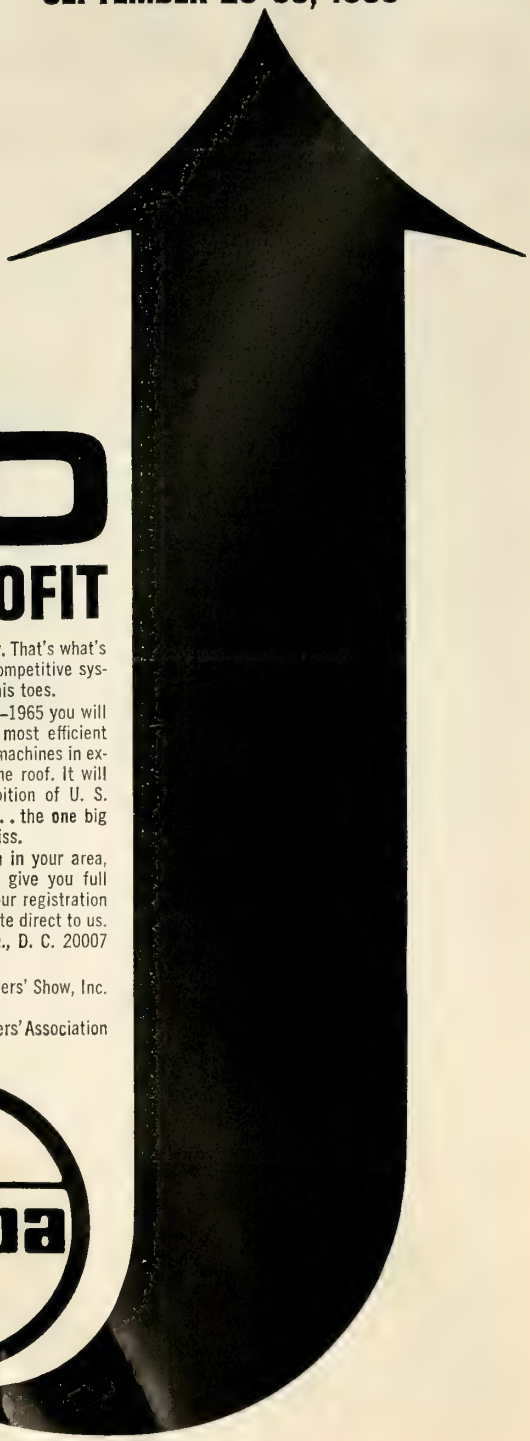

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An analog telemetry system is used, transmitting data to the NASA Minitrack station located adjacent to the Research Station site. The telemetry is time-shared, with transmissions from two of the three bands being observed at any one time. The 10-mc-region transmission is always broadcast, normally in conjunction with the 5-mc. However, in areas where electron densities do not permit passage of the 5-mc signals to the satellite, the 15-mc receivers are automatically switched on.

A pair of crossed coaxial loop antennas are used with this experiment, with a diplexer arrangement to allow sharing of the 5 and 15-mc units. Original plans called for use of ferrite rod antennas but these were dropped because of anticipated thermal problems.

Pye is building five of these solid-state units, which weigh 8½ lbs. each, including electronics and antennas. A second development model is now in test. A third model, a flight prototype, will be delivered in October, and the two flight models by April, 1966.

• **Other tests**—Three of the other four experiments aboard *UK-3*, which is being built by the British Aircraft Corp., are basically extensions of work begun with earlier satellites in the series.

These other experiments include:

—A Manchester University experiment will expand upon galactic noise measurements begun in *UK-2* by adding a direction-sensing capability through use of the refractive properties of the ionosphere combined with aspect sensors on the satellite. The satellite will carry a large loop antenna, stretched about the tips of the four satellite solar-cell booms, to feed a swept frequency receiver.

—The Birmingham University experiment will involve two sensors to measure electron density and temperature. The density sensor is similar to the *UK-1* device and also to one aboard the French satellite *FR-1*. It includes a pair of grids, acting as a parallel plate capacitor, inserted in one arm of an RF capacitance bridge. The second sensor is similar but uses circular grids for the temperature measurement.

—The U.K.'s Meteorological Office experiment is similar to one carried aboard *UK-2* which measured the vertical atmospheric distribution of ozone, but the system aboard *UK-3* will operate in a different wavelength to examine the related distribution of molecular oxygen.

—The Sheffield University experiment, like the Research Station device, is new to the *UK* series. This unit will measure propagation of VLF (below 20 kc) signals within the ionosphere. This experiment requires a second large loop antenna inboard of the one for the Manchester University experiment. ■

New Filament Winder Can Make 260-in. Cases

WORK IS SCHEDULED to begin within the next 2 weeks on a filament-wound 260-in.-dia., 55-ft.-long experimental motor case at Aerojet-General Corp.'s Todd Shipyards in San Pedro, Calif.

The case will be built for the Manufacturing Technology Div. of the Air Force Materials Laboratory in an effort to prove the feasibility of winding such big cases. The first case will be hydrotested but not fired.

The huge winding machine, its supporting feet spread over 7,500 sq. ft. to distribute the load, is expected to lay groundwork for super-size boosters.

Aerojet spokesmen also say the company has studied the possibilities of winding experimental submarine hulls and giant cocoons within which to hydrotest submarine structures.

● **State-of-the-art winder**—The 400,000-lb. machine is capable of being extended to produce 260-in.-dia. cases up to 100 ft. in length. It was designed, fabricated and installed—excluding the tension package and mandrel, built by Aerojet—by The Rucker Co., Oakland, Calif. Fred Brinkel, Rucker mechanical group supervisor, said the company incorporated conventional equipment and materials in the winder, extending and enlarging technology Rucker had developed in smaller machines. Aerojet also operates the country's next largest filament winder, which produces vessels more than 96 inches smaller in diameter.

The new machine can support a 200-ton mandrel and an 8-ton tension package assembly. Electro-hydraulic devices control accuracy of positioning to within ⅛ in. along a 160-ft. linear run of the filaments as the load rotates.

Biggest design challenge was transmission of highly accurate coordinated power to the mandrel and traveling filament package, according to Rucker. The firm considered both a straightforward hydraulic servo-control and direct gear drive, but finally chose a combination design. Power is delivered through a direct-ratio gear box to the revolving mandrel, while a hydraulic servo-drive pulls the 8-ton tension package assembly along the 210-ft. oval track surrounding the work piece.

● **Machine description**—The machine consists of three basic packages. A headstock at one end supports half the weight and transmits main driving power. The structure is 60 ft. long, 40 ft. wide and 19 ft. high, constructed of steel I-beams of sections 1 in. thick. A tailstock supports the opposite end. Four 2,000-psi, 8-in.-bore hydraulic cylinders raise and lower the mandrel over a 9-ft. range to permit longitudinal wrapping.

Collapsed dimensions are 15 ft. wide, 10 ft. high, 6 ft. deep. A track and carriage assembly running a 210-ft. periphery around the work piece has an I-beam guide rail that supports the carriage carrying the tension package with its 60 filament spools. Spools are 1 ft. in diam., 6 in. wide and weigh 35 lbs. Filaments from the spools produce a flat 5-in.-wide tape that is fed directly onto the vessel being wound.

The 10-ft.-long carriage is suspended from two trolleys hanging from the guide track. It is powered through a triple-width roller chain, the heaviest standard section available, which moves on its circumferential orbit at controlled speeds of up to 400 fpm.

The main transmission assembly achieves synchronization between mandrel carriage and drive by means of a master gear box driven by a variable-speed drive. On a longitudinal pass, the filament carriage makes 165 circuits in one complete turn of the mandrel to accomplish one complete wrap. This can be increased to 180 circuits. On a circumferential wrap, the carriage normally advances 2½ in. for each mandrel turn, with variance between 2⅜ and 3 in. possible.

The mandrel was designed for direct mechanical drive from the transmission assembly through a reducing box with a worm ratio mechanism. To counteract uneven stresses in the winding process, an eccentric counterbalance handles up to 10,000 ft.-lbs. of uneven load.

The problem of longitudinal expansion of the mandrel in curing of the case, heated under a hood for several days, was solved by roller ways, which allow expansion of the tail stock area. To simplify removal of the segmented mandrel and the completed case, the tail stock and track assembly are modularized to permit rollaway removal of the work piece on a mobile supporting structure.

The entire winding operation is controlled from an operator's console and pushbutton station. Direction and type of wrap are preselected. ■

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GT-4 Adds to Visual Acuity Debate

White, McDivitt distinguish details almost as small as those reported by Cooper; Douglas tests how zero-g affects vision

by Heather M. David

THE RECENT *GEMINI* flight brought additional indications that visual perception in space may be vastly superior to Earthbound performance.

Astronaut Edward H. White said he could see "much greater detail than I could just flying from an aircraft at 40,000 feet." He told of seeing roads, wakes of boats, and "fine strings of lights where the street lights and the roads were lighted." From outside the spacecraft, he said, he could see outlines of small lakes quite clearly.

"The thing that impressed me was the clarity with which you could see objects down there," White told reporters. "We looked down at roads. You could see airfields. You could see the runway outlines very clearly."

Astronaut James A. McDivitt added that the contrast between the thing being viewed and the surrounding terrain was very important. He also noted that long features tend to stand out better than do square ones.

Much debate has centered around the question of exactly how much and how far astronauts really have been able to see in their spaceflights. The speculation began after the *Mercury-Atlas 9* flight, when Gordon Cooper told of seeing chimneys in Tibet and roads and what he thought was a truck along the U.S.-Mexican border.

Previous estimates for acuity of the human eye were one minute of arc. Cooper's observations, made at 100 miles, indicated a much smaller angle. His experience was borne out by considerable testing by NASA and the Scripps Institute, a research group expert in the field.

However, NASA scientists were cautious about speculating that weightlessness improves vision.

NASA will further test Cooper with a special experiment planned for *GT-5*.

Interest in the subject has led the Air Force to a series of studies. In a contract with Douglas Aircraft Co.'s Missile and Space Systems Division, it was demonstrated that brightness discrimination—a direct and fundamental test of visual functioning—is quite definitely improved in weightlessness.

● **Method of test**—Six subjects, all civilian and military personnel of the Aerospace Medical Research Laboratories, were selected. Ranging in age from 20 to 28 years, all had normal eyes with a visual acuity of 20/20 in both eyes without glasses.

The subjects were flown in a C-131B aircraft in a Keplerian trajectory, producing weightlessness from 10 to 14 seconds, with an average of 11 seconds.

The plane flew two parabolas in one double maneuver at each pass, with a total of 15 double maneuvers during each test. A special apparatus was installed in the fuselage for testing the subjects, who lay in a semi-supine position on special fixed net couches.

Above the test subject a box-like apparatus carried the visual display. It consisted of an achromatic circular target—a white light—projected on an achromatic circular background. Angles of 1.5 and 2.6 degrees respectively, for the target and background were subtended.

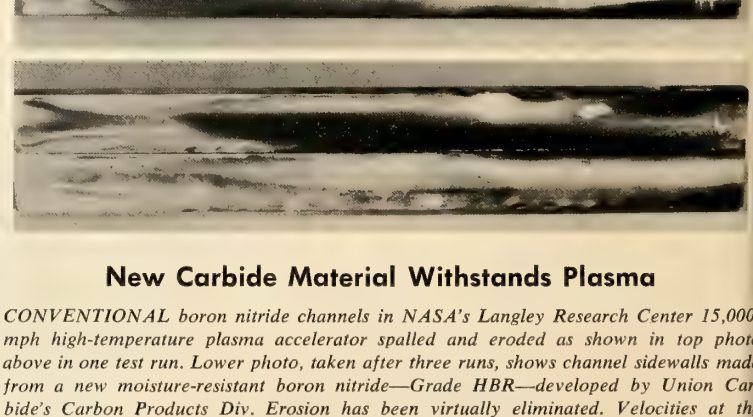
All the windows of the aircraft in the fuselage section were covered, and the subject and display were enclosed in a light-tight cloth hood to keep out any ambient light.

Trick of the test was to pick out the target light against a lighted background. Five 25-watt bulbs behind two sheets of flashed opal were used for the background. A 300-watt slide projector was used to project the target onto the rear surface of the viewing screen.

Background luminence was varied with the use of neutral-density filters placed in front of the viewing screen.

Each subject was given a response button, which he was told to punch when the luminence of the target increased to the point where he saw it against the background. He then allowed it to decrease until he could no longer see it before pushing it again.

The subjects were required to per-



New Carbide Material Withstands Plasma

CONVENTIONAL boron nitride channels in NASA's Langley Research Center 15,000-mph high-temperature plasma accelerator spalled and eroded as shown in top photo above in one test run. Lower photo, taken after three runs, shows channel sidewalls made from a new moisture-resistant boron nitride—Grade HBR—developed by Union Carbide's Carbon Products Div. Erosion has been virtually eliminated. Velocities at the exit of the accelerator reach 6,850 meters/second, and the extremely low moisture pickup of the HBR material prevents the spalling characteristic of most high-temperature materials. The facility is used primarily for re-enty testing.

form the test during the weightless condition, at 1 g while the aircraft was flying straight and level, and at 1 g immediately after a 2.5-g turn. During a double parabola, four alternate ascending and descending threshold determinations were possible.

After 36 runs, the research group, led by Dr. W. J. White, reported that it had statistically significant differences.

● **Results**—Threshold figures—the measure of the percentage difference between the brightness of the target and the background—for weightlessness and 1 g were compared.

It was found that under low lighting conditions—0.03 ft.-Lamberts—the average percentage difference necessary to detect the target at 1 g was 15.14%. During weightlessness, however, the subjects were able to make the detection at 12.56%. Decrease in the dimmest conditions was most marked of the three measured.

In a medium light, 0.28 ft.-Lamberts, the percentage necessary at 1 g was an average 7.05%; in weightlessness, 6.49%. In a bright light, 30.0 ft.-Lamberts, subjects at 1 g required a percentage contrast of 4.45%; in weightlessness, 3.99%.

One-g responses after the 2.5-g pull-up were found to be not consistently different than those at 1 g before the maneuver.

● **Why**—Douglas researchers report that the difference seems to be in the functioning of the oculomotor mechanism itself, rather than in neural pathways or dioptrics of the eye.

It has been well understood that the normal human eye is constantly in motion. It "dithers" with a tremor or physiological nystagmus with an angular extent of an average of from 10 to 20 seconds of arc, or half the diameter of a single-cone receptor. These involuntary movements, the Douglas group reports, may range from 20 to 150 cycles per second. Their purpose appears to be as an averaging mechanism which rectifies the image on the retina or the means by which the illumination on a given receptor is rapidly changed from one level to another, with consequent increase in effective stimulation, the Douglas researcher said.

In other, independently conducted, research, it was discovered that if the retina image were immobilized, objects viewed rapidly faded out and ultimately disappeared. This fading subsequently could be abolished by doubling the motion found in normal vision.

Thus, the Douglas researchers postulated, if the retinal image had an exaggerated motion, it could account for the decrease in contrast required to detect a target during weightlessness. This would mean that there was an increase in physiological nystagmus during weightlessness.

Dr. White suggested that the eye could be thought of as a dynamic system with the tissues which govern the dynamic response of the eye as mechanical constants. During weightlessness, the mass remains constant, but the frictional and damping forces developed during movement probably would be decreased, he said. This could produce an increase in amplitude over the normal range of 10 to 20 seconds of arc, producing the exaggerated motion which previously had been demonstrated as a way to overcome fading vision.

This theory is supported by the fact that vision decreases during high accelerations because of a progressive loss of ocular mobility. Acceleration, or increased g, would increase the friction and/or damping forces created between the eyeball and its supporting structure, the researchers said.

In reporting the experiments, White termed the work "exploratory," pointing out that there were many factors, which, because of the nature of the in-flight research, require compromise. Additional flight testing with sophisticated instrumentation is needed to fully test out the hypothesis, he said. ■

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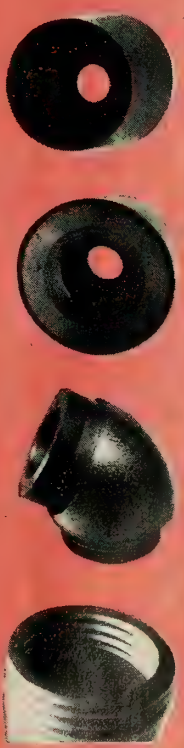

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Assembly-in-Orbit Plan Promising

General Dynamics/Convair concept envisions erection tools that could be either automatically or manually controlled

by Willard E. Wilks

GENERAL DYNAMICS/CONVAIR is developing an automatic assembly-in-orbit concept that looks promising for application to a variety of large structures, including antennas and solar concentrators, booms, space stations, re-entry bodies and lunar shelters.

Theoretically, there is no limit to the size of the space structure that may be assembled with the technique, whereas size and dimensional stability reach limits with unfolding or inflatable devices, engineer Paul Slysh told MISSILES AND ROCKETS.

Originally conceived as a method to build a large radio telescope in orbit, the concept still is known as RATIO, but now has been investigated as a means to automatically build almost any structure in space. The assembly equipment also could be manually controlled.

● **Once considered for MOL**—In the *Manned Orbiting Laboratory (MOL)* RFP for the P-14 experiment involving a large structures study, RATIO was the first item listed for study, although Convair did not bid on that parallel RFP.

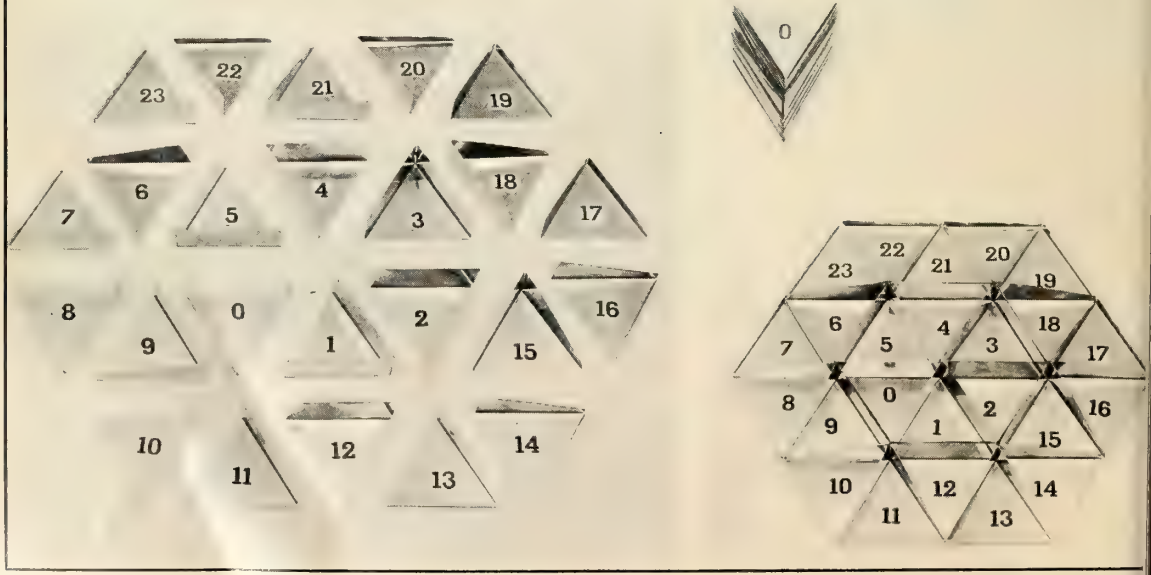
The division has completed a study for NASA after proposing that the method be used to construct a single large polar-orbiting antenna that would replace, with an extended capability in the 1970-80 period, the Deep Space Instrumentation Facility (DSIF) antennas operated by the Jet Propulsion Laboratory.

The study for NASA concerned the structural problem areas associated with a steerable antenna in space, considering the distortions expected from action of the attitude control system. Jets could be used for control, with drivers located at several points on the structure.

An unsolicited proposal also has been made to Air Force to utilize the technique for assembling the solar concentrator in the Advanced Solar Turboelectric Concept (ASTEC).

● **What it can do**—Slysh described RATIO at the recent Second Annual Expandable Structures Conference at Minneapolis. He illustrated the technique at the conference by describing its application to the deployment of a paraboloidal reflector for an antenna

ASSEMBLY of the panels of reflector structure planar model takes place according to a systematic sequence of relative motions between successive panels. Panel 1 is assembled to panel 0 by a counterclockwise rotation and linear displacement of panel 1 with respect to panel 0. The same rotation and linear displacement takes place between panels 2 and 1, 3 and 2, 4 and 3, and 5 and 4. Panel 6, however, is assembled to panel 5 by a clockwise rotation of the stack with respect to panel 5. Examination of illustration on page 39 indicates positions of panels as part of a space station antenna.



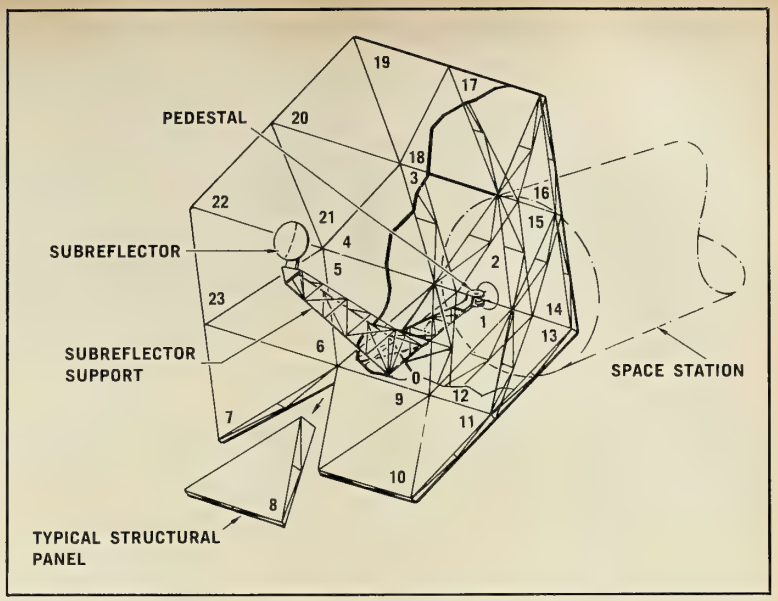
The chosen reflector has a hexagonal contour and is sectionalized into 24 triangular panels. The planar model on page 38 depicts the reflector sectionalized, stacked and assembled. Slysh told M/R the technique has these main features:

—It is generally possible to design space structures so they can be sectionalized into panels that nest in each other to minimize storage volume and susceptibility to damage by boost loads. Panel shapes can be chosen to satisfy available storage volume requirements. In the deployed state, the structures are ribbed, and have structural continuity.

—The assembly equipment consists of electric stepping motors that move on a floating rack frame and are equipped with screwdrivers or other tools to actuate screws or other captive fasteners. The motors generate linear or rotary action to take panels from a stacked position and assemble them.

—Each motor is controlled with a stored program, using solid-state digital-logic circuitry, telling the motor how many revolutions to make and in what direction to accomplish assembly through gear trains and linkages.

—It is estimated that for an antenna in the range of 30 to 200 ft., weight of the structure, including assembly equipment, would be 0.03 to 0.07 lb./sq. ft.



VIEW OF the reflector as part of a space station Cassegrain antenna. In this example, panel 0 is used for pedestal-mounting the antenna with respect to the space station and for mounting the sub-reflector with respect to the reflector. Panels 7, 8, 9, 11, 12, 14, 15, 17, 18, 20, 21 and 23 are assembled by clockwise rotations. These assembly motions are part of a single set of assembly motions. The sub-reflector support may be a RATIO, stretch-formed wire mesh or other expandable structure. In this case, the support and sub-reflector are stored between panels 0 and 1 and deployed after panel 1 is assembled to panel 0.

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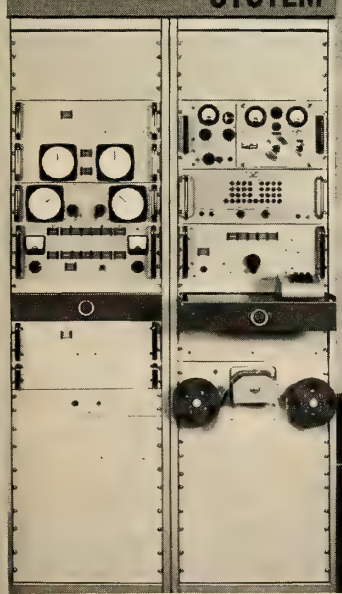

Frequency: 2150-2350 Mc.
Gain: 37 db.
Side-lobe level:—18 db.
Polarization: Hor. or vert. linear, RH or LH circular.
Acquisition angle: 5°.
Scan frequency: 30 cps.
Tracking sector: 720° azimuth, 180° elev.
Tracking velocity: 15°/sec.
Tracking acceleration: 15°/sec².
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Up to nine motors, with an input of 50 watts, would be required. Typical preliminary design estimates indicate that for 30 to 200-ft. reflector structures having structural weights on the order of 0.05 lb./sq. ft., the automatic assembly equipment weight ranges from 50-100% of the structural weight for smaller structures to 10-20% for the larger structures.

—The panels and mechanisms may themselves be rigid or expandable structures, and assembly equipment may be used for repair or disassembly in space after a structure is in operation.

—The assembly sequence may be programmed so that any panel of an antenna or other structure is attached to a space station to facilitate access for control, repair or maintenance. Since the assembly equipment is generally more rigid than the structure, it can be used to pull the structure into alignment or as an antenna attitude-control pedestal.

—Size of the structures that can be assembled is mainly limited by the number and sizes of panels that can be orbited. The same assembly equipment can be shifted to a new stack to continue operations after disposing of one stack.

—The assembly equipment can be designed to serve other space station materials-handling functions when its assembly work is complete. It can carry a panel-to-panel position register system, and can be used for separate handling of fixed or variably adjusted dummy panels, which may be substituted for damaged panels.

Slysh reports that antenna and solar concentrator structures appear to be the most difficult structures to handle with the RATIO technique because of the dimensional stability problem.

● **Accuracy cited**—"A primary advantage of the concept is that you can produce much more accurate structures than with other approaches," he said. "This is because each panel is fabricated in the factory out of rigid metal, each panel can be joined rigidly to the adjoining panel, and the entire structure can be assembled and tested on the ground. Fasteners are built right into the panels."

Slysh believes the inflatable or unfurling approaches makes the most sense for small antennas, but RATIO begins showing advantages over other systems above 30 ft.

The technique also shows great advantages over ground-based antennas where large sizes are concerned, according to Slysh. One large antenna in orbit, or several smaller ones, could permit live television or voice link between Earth and Mars without encountering the transmitter power and antenna size problems presented otherwise.

For antennas running over 300-400 ft., Slysh believes building them in orbit with the RATIO technique would be cheaper than basing them on Earth. "Building steerable parabaloid antennas of 1,000-2,000 ft. on the ground might be completely unthinkable," he said, pointing out that wind, gravity loads and shifting of structural foundations would not be encountered in space, and that thermal distortion would be smaller.

"In evaluating what can be done with big antennas in space, you have to consider radio astronomy," Slysh said. "In ground-based operations, going below 10 mc and above 10 gc is impossible because of atmospheric and ionospheric absorption. These problems could be avoided with an orbiting system. Also, with the RATIO technique, you could build triangular girder-like structures, extending 10,000-20,000 ft., on which dipoles could be mounted."

Convair has a small, hand-operated model to demonstrate the RATIO technique. While studying its application to automatic assembly of lunar structures, Slysh saw a possible future application.

"It's far out, but you could envision a house so designed with all utilities built into the walls, that the owner can have it automatically dismantled, transported and re-assembled at a new location." ■

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Mergers and Acquisitions

Nuclide Corp., State College, Pa., has acquired the Equipment Div. and certain other activities of Alloyd General Corp. of Cambridge, Mass. Aim of the cash transaction is Nuclide's diversification into the electron beam field and the acquisition of additional production facilities and staff talent. The acquisition will be operated as the Alloyd-General Vacuum Div. of Nuclide. Nuclide's Boston operation, which manufactures RF mass spectrometers and electronic apparatus such as regulated high-voltage supplies and ion gauge controls, is being moved to the AGV Div.'s plant in Medford, Mass. . . . *The boards of directors of International Telephone and Telegraph Corp. and Universal Controls, Inc., have approved a letter of intent with respect to the sale of UC's principal assets to ITT. The transaction remains subject to approval of UC's stockholders, the obtaining of favorable tax rulings and other conditions. UC units involved in the deal would be the American Totalisator Div.; C. P. Clare & Co., a wholly owned UC subsidiary; and two smaller operations, the General Register and Grant Money-Meters divisions.*

Showdown Looms at ARC

Atlantic Research Corp., stockholders on July 10 will decide which of two warring factions will control the company. A "management" slate, including ARC president M. Lee Rice and two members of the present board, and headed by Dr. Arthur W. Sloan, ARC vice chairman of the board and chief executive officer, will seek to retain control of the Alexandria, Va.-based aerospace firm. Attempting to gain control from Sloan's group is ARC board chairman and largest stockholder Dr. Arch Scurlock and a "Committee for Progressive Management of ARC," which includes, besides Scurlock, one member of the present board and three other nominees. Sloan and Scurlock were co-founders of ARC, a firm that since its formation in 1949 has risen to 29th place among DOD prime contractors for research, development, test and experimentation. Scurlock was president and chief executive officer from 1949 until Nov., 1962, when the board "found it necessary to declare vacant the positions (of president and chief executive officer) . . ." following a "review of some matters made the subject of inquiry by the Securities and Exchange Commission and after due deliberation by the board of directors upon the problems then facing the company" (M/R, Oct. 29, 1962, p. 51). Sloan at that time resigned as board chairman and was made chief executive officer. Scurlock was "kicked upstairs" beyond executive decision making to the board chairmanship. An uneasy peace existed between the two men from that time until last month when, according to the Progressive Management Committee, Sloan moved during a board meeting to exclude Scurlock from the management slate for the upcoming board election. The existing management said in its proxy letter that the "future welfare of the company, including solution of the remaining problems and improvement of stockholder, customer and creditor confidence requires that Dr. Scurlock not participate in management of the company." Sloan and Rice view ARC management's main tasks as lying not only in carrying forward the company's business and making a profit, but also in solving the problems "raised under the previous regime that Scurlock was largely responsible for." Scurlock's group, on the other hand, points to lagging sales and profit margins since 1962 as evidence that under present leadership the firm offers "little promise of growth." The Progressive Management Committee proposes among other measures increasing the number of company directors to 11 and an addition to the firm's management of a senior vice president-finance, who would be assigned broad financial and business responsibilities and who would report to the chief executive officer.

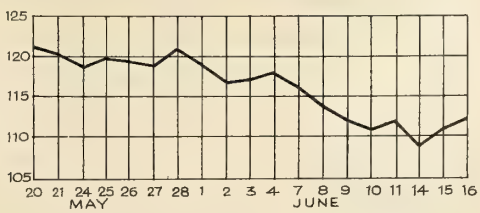
$12-Billion Market Seen for AGE

The president of the Electronics and Space Div. of Emerson Electric Co. predicts an electronic aerospace ground equipment market of $12 billion in another 5 years. Dr. Robert L. San Soucie told an IEEE symposium on "Automatic Support Systems for Advanced Maintainability" in St. Louis that, based on detailed studies of current DOD and NASA plans, the annual rate of expenditure for electronic ground support equipment will have been doubled.

International

Alpha Microelectronics Co., Inc., of Beltsville, Md., has concluded a licensing agreement with Airtronics of Sevres, France, whereby La Microelectronique, a new department of Airtronics, will be authorized to use techniques and products similar to those developed at AME. . . . *The Boeing Co. has joined Cavaliere del Lavoro Carlo Rodriquez of Messina, Sicily, and l'Intituto per lo Sviluppo delle Attivita' Produttive in sponsoring a new Italian company for development of advanced marine craft.*

Missile/Space Stock Index



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
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- ☐ Seal-Off Valves #209

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contracts

AIR FORCE

$4,130,000—**Marquardt Corp.,** Van Nuys, Calif., initial increment to a $15-million contract for classified work.

$4,053,154—**Electronic Specialty,** Los Angeles, for aerospace ground equipment.

$3,990,015—**Lockheed Aircraft Corp.,** Lockheed Missiles and Space Co., Sunnyvale, Calif., for production of *Agena* boosters.

$3,177,367—**The Boeing Co.,** Seattle, for missiles and related equipment.

$2,052,636—**The Bendix Corp.,** Teterboro, N.J., to make computers and amplifiers.

$1,500,000—**Goodyear Aerospace Corp.,** Litchfield Park, Ariz., to build six semi-trailer trucks to move *Minuteman II* missiles from production lines to silo installation.

$1,304,403—**The Boeing Co.,** Seattle, for spares and ground and training equipment.

$1,000,000—**General Dynamics, Inc.,** Fort Worth, Tex., for radar equipment.

$1,000,000—**Lockheed Aircraft Corp.,** Marietta, Ga., for the provision of services in performance recording.

$740,909—**United Aircraft Corp.,** United Technology Center, Sunnyvale, Calif., for investigation of prepackaged hybrid propulsion systems.

$709,000—**Weinschel Engineering Co., Inc.,** Gaithersburg, Md., to supply commercial pulse power and signal generator calibrators.

$698,097—**Thiokol Chemical Corp.,** Reaction Motors Div., Denville, N.J., for combustion chamber techniques for advanced prepackageable propellants.

$324,621—**University of Denver,** Denver Research Institute, Denver, Colo., for research directed toward instrumentation and services to measure physical characteristics of simulated lunar and planetary soils.

$301,300—**Archer Daniels Midland Co.,** Minneapolis, for research optimization of expandable self-rigidizing honeycomb for future space applications.

$262,000—**Raytheon Co.,** Space and Information Systems Div., Bedford, Mass., for investigation of ionospheric wave guidance mode.

$249,873—**Hughes Aircraft Co.,** Research and Development Div., Culver City, Calif., for research on advanced array techniques.

ARMY

$4,520,000—**American Electronic Laboratories,** Colmar, Pa., for electronic equipment.

$4,229,666—**Collins Radio Corp.,** Dallas, for intercommunications systems at Merritt Island, Fla.

$1,327,884—**Emerson Electric Co.,** St. Louis, for *Honest John* rocket motors, inert parts.

$1,250,000—**Radio Corp. of America,** New York City, for missile test equipment.

$1,082,770—**Smith-Sundt,** Compton, Calif., for *ABRES* modifications, pads 1 and 3, Vandenberg AFB, Calif.

$351,258—**Akwa-Downey Construction Co.,** Milwaukee, for electrical modifications and alterations to fluid lines for spacecraft propellant testing equipment at NASA's Merritt Island Launch Area.

$137,000—**Rohm and Haas Co.,** Redstone Arsenal Research Div., Redstone Arsenal, Ala., for continuation of a program of design, development, fabrication and testing of a prototype hybrid propulsion system.

NAVY

$8,722,363—**Baifield Industries, Inc.,** Los Angeles, for continued production of the *Snakeye* weapons system.

$3,226,500—**Humphreys and Harding, Inc.,** Washington, D.C., to build a structural mechanics laboratory in Carderock, Md.

$2,707,029—**North American Aviation, Inc.,** Rocketdyne Div., McGregor, Tex., for rocket motors.

$2,596,000—**Western Electric Co.,** Hillside, N.J., to make oceanographic research equipment.

$1,793,000—**Sperry Rand Corp.,** Sperry Gyroscope Co., Great Neck, N.Y., for research and development program on *Talos* fire control system, radar sets, computers and weapon direction equipment.

$1,585,250—**Baifield Industries, Inc.,** Carrollton, Tex., for *Snakeye* bomb fins.

$400,000—**Radio Corp. of America,** Communications Systems, Div., Camden, N.J., for a classified program.

$376,317—**Motorola, Inc.,** Military Electronics Div., Scottsdale, Ariz., for production of *Talos* target detecting device.

$75,000—**Thiokol Chemical Corp.,** Elkton, Md., for evaluation of a new oxidizer in solid propellant formulation.

NASA

$3,216,000—**E. A. Hathaway and Co.,** San Jose, Calif., for construction of space flight guidance research facility at Ames Research Center.

$1,680,900—**Electronic Associates,** West Long Branch, N.J., for a hybrid computer.

$757,200—**Electro-Mechanical Research, Inc.,** College Park., Md., for *Imp F* and *G* integration.

$724,407—**Goodyear Aerospace Corp.,** Akron, Ohio, for passive geodetic satellite canister assemblies.

$720,000—**Philco Corp.,** Western Development Laboratories, Palo Alto, Calif., for modification of the Mojave 40-ft. antenna into an *Applications Technology Satellite* tracking facility.

$482,500—**United Aircraft Corp.,** Pratt and Whitney Aircraft Div., East Hartford, Conn., for *Apollo* fuel cell powerplant and 52 single fuel cells.

$408,900—**Radio Corp. of America,** Service Co., Camden, N.J., for spare parts for space environmental simulation laboratory solar simulation system.

$397,439—**General Dynamics Corp.,** Convair Div., San Diego, Calif., for the design of a cylindrical thrust structure.

$185,540—**LTV Aerospace Corp.,** LTV Astronautics Div., Dallas, for preliminary design and fabrication of second generation space capsule prototype.

$179,263—**Statham Instruments, Inc.,** Los Angeles, for high temperature pressure transducers.

$108,000—**Greenhut Construction Co., Inc.,** Pensacola, Fla., for miscellaneous additions to advanced *Saturn* dynamic test stand.

$90,500—**Lockheed Aircraft Corp.,** Palo Alto, Calif., for *Scout* operational performance program.

$86,056—**North American Aviation, Inc.,** Rocketdyne Div., Canoga Park, Calif., contract modification for design, development, fabrication, evaluation and delivery of a breadboard upper stage fire detection system for *Saturn* vehicle.

$50,000—**Westinghouse Electric Co.,** Baltimore, for satellite mobility study.

$39,950—**Mitron Research and Development,** Waltham, Mass., for study to reduce vibration in spacecraft.

$29,416—**Allied Research,** Concord, Mass., for photomechanical investigation of stresses in motor nozzles.

$29,120—**Itek Corp.,** Vidya Div., Palo Alto, Calif., for services to provide and modify computer programs relative to ablation material behavior research.

Lockheed Aircraft Corp., Lockheed-California Co., Burbank, Calif., for engineering support for Manned Spacecraft Center (amount not disclosed).

INDUSTRY

$1,250,000—**Pneumo Dynamics Corp.,** Cleveland, Ohio, from **The Boeing Co.,** Seattle, for safety ventilation valves for the *Minuteman* launch control center program.

$800,000—**Ryan Aeronautical Co.,** San Diego, Calif, from **TRW/Space Technology Laboratories,** Redondo Beach, Calif., for titanium engine chambers and chamber shells to be used in the LEM descent rocket engine.

$350,000—**Computer Control Co., Inc.,** Los Angeles, from **The Boeing Co.,** Seattle, to supply computers for use in *Minuteman* system.

$300,000—**Whittaker Corp.,** Controls and Guidance Div., Chatsworth, Calif., from **Maxson Electronics Corp.,** Great Neck, N.Y., for gyroscopic systems to be used by the Navy *AQM-37A* rocket-powered supersonic target missile.

$150,000—**International Telephone and Telegraph Corp.,** ITT Industrial Products Div., San Fernando, Calif., from **Lockheed Aircraft Corp.,** Lockheed International Div., Los Angeles, for additional power supplies for launching *Sidewinder* missiles from the wing tip of the F-104.

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AIR FORCE WESTERN TEST RANGE

Mission: Master Critical Instrumentation Problems

The testing of missiles and space vehicles is one of the Air Force's most crucial problems. Successful control of the complex machines of the space age and acquisition of data through them are achieved by highly sophisticated instruments. These instrument-generated results are the basis for new ideas and advances in aerospace. A wide-ranging imagination and strong initiative are imperative qualities in the people who control the machines and instrument the data.

At the Air Force Western Test Range (AFWTR) a dedicated civilian-military team maintains and operates the Western Test Range of the National Range Division—an area covering the Western States to the Indian Ocean. AFWTR has management responsibility for facilities that support range operations in this area, providing key links in tracking, command, telemetry and communications.

AFWTR is seeking qualified scientists and engineers with a minimum of one to three years' experience who seek growth potential in challenging assignments. Required are creative, technically proficient people for positions in systems-oriented instrumentation work. These rewarding positions are presently available in the Career Civil Service.

MATHEMATICIAN OR ELECTRICAL ENGINEER—Data System Analyst to assist in the preparation of computer programs. Aid in the evaluation of performance of range instrumentation and launch operations. Aids in the solution of engineering problems, processing data by means of IBM 7094 and 1460 computer equipment. Evaluate Range user requirements for studies and analyses that employ digital computers. BS in mathematics and one to three years' experience in application of advanced data processing equipment in a scientific environment is desirable.

ELECTRONIC ENGINEERS (INSTRUMENTATION)—Aid in development, evaluation and utilization of instrumentation systems used for gathering data from space vehicles, guided missiles and aircraft. Systems will measure and analyze trajectory, velocity, position in space and other parameters. Data acquired from flight information and weapons system components are to be in such form as to permit rapid, large-volume reduction by computer and display. Instrumentation systems must approach laboratory accuracy yet work reliably with minimum maintenance under adverse field conditions. A high degree of imagination and initiative are necessary in planning and carrying out programs. Knowledge of aircraft and missile characteristics required as well as skills based on the sciences involved in systems design. BS degree desirable.

ELECTRONIC ENGINEER (TELEMETRY INSTRUMENTATION)—Aid in developing ground telemetry stations. Systems are to provide up-to-date facilities for measuring, analyzing and displaying missile flight and test data and reducing this data. Measurements include altitude, acceleration, velocity, flight path characteristics and performance of components. Work is expected to result in original solutions which will set precedents for other facilities and influence new instrumentation and techniques in industry. BS degree desirable.

ELECTRONIC ENGINEER (PULSE & DIGITAL INSTRUMENTATION)—Aid in development, evaluation and testing of instrumentation and other electronic test-range equipment employing pulse and digital circuitry. Equipment will be used to track and maintain control of test vehicles in and outside of the atmosphere, acquire and analyze flight-test data and for range safety. Assist in developing complex electronic systems involving aerodynamic and thermodynamic variables for high-speed aircraft and missiles. Work is expected to result in significant advances in the state-of-the-art of missile and space instrumentation. A high degree of originality and judgment is required. BS degree desirable.

Send résumé or Federal Employment Application Form (SF-57) to:

Civilian Personnel Office
Vandenberg AFB, Dept. MR-621
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LOOK AT LOCKHEED IN AGE ELECTRONIC SYSTEMS

Lockheed Missiles & Space Company has immediate need in Aerospace Ground-support Equipment Electronics for qualified engineers able to meet the following qualifications:

Must be able to project AGE systems from concept to point of sale. Will develop specifications and reports, direct technical proposal activity, lead other engineers, and improve or correct their concepts into a workable and saleable hardware system.

AGE systems include launch base equipment, computer controlled data processing systems, and digital hardline command systems.

Requires knowledge of magnetic interference problems, space systems testing experience, and perhaps some digital systems background plus, of course, a degree in Electrical Engineering. Ideally, we are looking for technical level supervisory types who would rather apply their technical knowledge in a practical manner.

Please write Mr. K. R. Kiddoo, Professional Placement Manager, Lockheed Missiles & Space Company, 530 Industrial Relations Building, Post Office Box 504, Sunnyvale, California.

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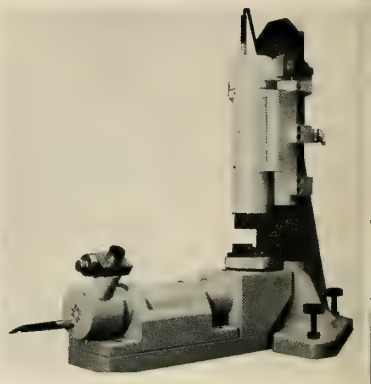
products and processes

New Product of the Week: Interferoscope System

An interferoscope system for measurement of parallelism, flatness and surface finish of crystal faces is being marketed by Systems Research and Development Co.

The device, the Model IF-110, permits inspection of opposite faces of a crystal in one operation and without subjecting critical surfaces to potential damage. In operation, phasal differences between reflected light beams give interpretable light-fringe patterns that are a function of the comparative flatness and parallelism of the master flat and the adjacent surface of the test specimen. The unit measures parallelism to an accuracy of less than one second of arc; flatness to 1/20 of a wavelength and surface finish in the microinch range.



Standard instruments accommodate samples up to 6 in. long and 3 in. in diameter. Extended ranges are available on order.

Circle No. 151 on Subscriber Service Card

Photon Scintillator

A photon scintillator, designed for counting of low-level light pulses—such as are found in radiation detection crystals—has been announced by Princeton Div. of Electro-Mechanical Research, Inc.

The detection technique is incorporated in the Model 579 G-08-MPA photon scintillator detector assembly, designed for photon counting in the ultraviolet. Detection of a single photon of energy is possible, developers say.

The basic detector principle consists of preamplifying the photons by a non-secondary emission process. The preamplifier is a sealed-off vacuum tube consisting of a photocathode, an electron optic system and an anode phosphor. The tube is optically coupled to a photomultiplier for scintillation counting.

The 9/16 in. cathode has a typical quantum efficiency of 8% at 1,216 Angstroms, with a background count of 1 per second at an electron gain of 24 at 20 kv. Typical peak-to-valley ratio is 4.3. The assembly is designed to withstand environments of 20 g's vibration, 30 to 3,000 cps.

Circle No. 152 on Subscriber Service Card

Gas Generators

A series of gas generators designed to produce a controlled burst of hot gas is available from the Aerospace Components Div. of Atlas Chemical Industries, Inc.

The D-1GG141 series can be used for any pressurizing or liquid transfer applications, the firm says. The units consist of cylinders of varying sizes which contain a grain of propellent and an ignition device that fires the propellent upon electrical impulse. Output of these devices is used principally for gas rather than for flame or igniting effect.

The generators are available with outputs of 50, 100, 225, 500 and 1,000 cc. (These nominal ratings refer to the ability of the generator to displace a similar quantity of water.) It takes 2.5 to 4 seconds for the device to displace the rated amount.

Circle No. 153 on Subscriber Service Card

Rectifier Bridge

Electronic Devices, Inc., has developed a 3-phase bridge silicon rectifier assembly, the Model ED7296.

The hermetically sealed unit is rated at 27,000v PIV and is capable of delivering 3 Adc. It measures 11 x 11 x 7.5 in. and meets MIL-E-16400 specifications.

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Backward-Wave Oscillator

A permanent-magnet focused backward-wave oscillator, voltage-tunable from 500 to 1,000 mc, is being marketed by Watkins-Johnson Co.'s Stewart Div.

The Type SE-223 measures 3 x 3 x 12 in. Operating life is 2,500 hours.

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The Ninth Annual World Missile/Space Encyclopedia provides year-round selling action with one low cost ad. It's the industry's year-round reference manual for data on U.S. and foreign missiles, spacecraft, sounding rockets, rocket engines and space systems. The Missile/Space Encyclopedia provides a unique showplace to maintain year-long contact with an effective audience of over 53,000* leading scientists, engineers, designers and management men — the people making the important defense/space buying decisions.

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PUBLISHED: July 26, 1965 ADVERTISING CLOSES: July 12, 1965

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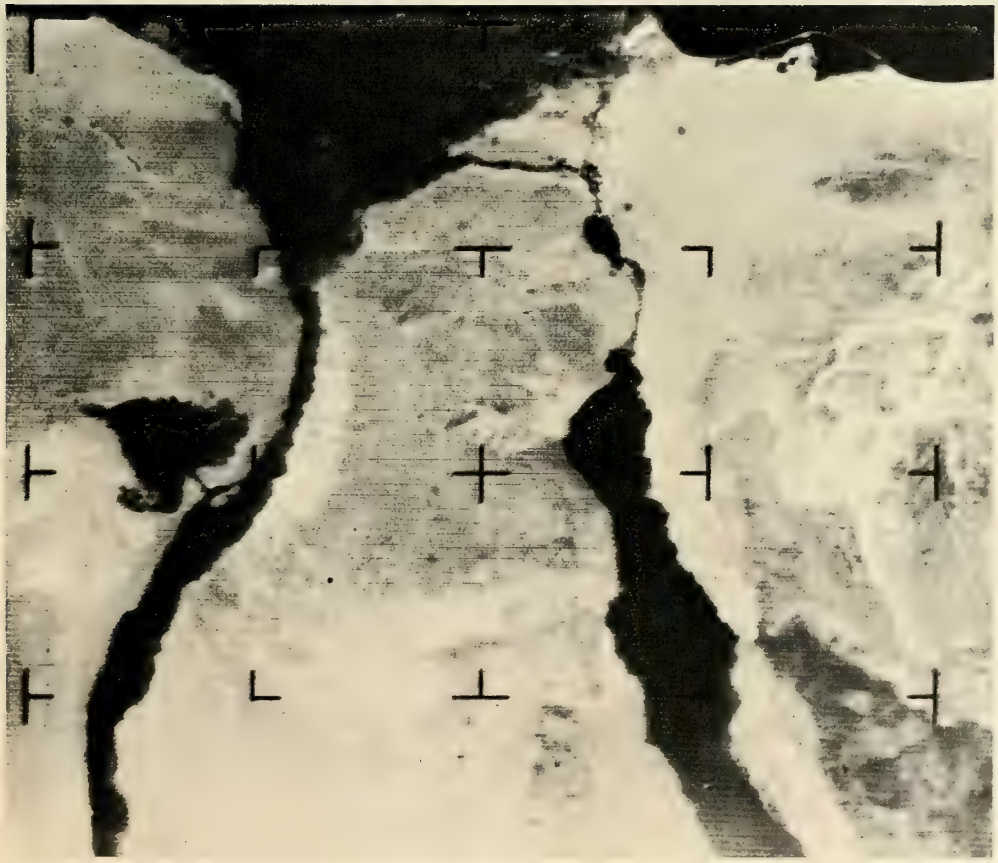

missiles and rockets

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1001 Vermont Ave., N.W., Washington, D.C. 20005

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IN SAN FRANCISCO

missile/space daily will provide complete coverage:

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Ten editors, under the direction of Bill Coughlin, VP and Editorial Director of AMERICAN AVIATION PUBLICATIONS, and Bill Hall, Editor of MISSILE/SPACE DAILY will be at the Show reporting all important developments.

advertising

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MISSILE/SPACE DAILY

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MISSILES AND ROCKETS

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names in the news

Richard W. Larrick: Named chairman of the public relations committee for the Second American Institute of Aeronautics and Astronautics Annual Meeting and Technical Demonstration. He is director of public relations for United Technology Center, a division of United Aircraft Corp.

James N. Davis: Joined Booz, Allen Applied Research, Inc., as vice president and director of Washington Operations. He was formerly Deputy Assistant Secretary of Defense. **Dr. George H. Shortley,** who has been vice president and director of Washington operations, became vice president and chief scientist.

Harry E. Burke: Appointed executive vice president of Huggins Laboratories, Inc. Before joining Huggins, he was vice president and general manager of Consolidated Systems Corp.

Dudley E. Browne: Re-elected president of the Financial Executives Research Foundation, research arm of Financial Executives Institute. He is group vice president-finance and administration, Lockheed Aircraft Corp.

Lt. Col. Richard W. Marshall: Named by Douglas Aircraft Co. as assistant manager for *Saturn IB* programs at Cape Kennedy. Soon to retire from the Air Force, he has been chief of *Thor* space programs at Eastern Test Range since 1962.

Wilmer Wright: Elected to the board of directors of Silicon Transistor Corp. He is president of Wright Associates, Inc., a management consulting firm.

Sidney Krakauer: Appointed vice president-new products of Pall Corp. He will be in charge of research and development work on all new products.

Dr. Carl A. Frische: Elected to Sperry Rand Corp's board of directors. He is president of Sperry Gyroscope Co.

Lt. Gen. Harvey T. Alness (USAF, Ret.): Appointed senior European representative of General Dynamics Corp.

Robert A. Howland: Named assistant project manager for the Project *Apollo* positive expulsion tank programs at Bell Aerospace Corp's Bell Aerosystems Co. **A. Bruce Horton, Jr.,** has been appointed manager of the Electronic Range Dept., which is responsible for the operation and maintenance of the U.S. Army's Electromagnetic Environmental Test Facility and Drone Test Range in southern Arizona.

Robert W. Hodgers, Jr.: Appointed vice president of the newly created Information Systems and Services Dept. of Western Union. He will be responsible for all research, development and applied engineering functions.

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1001 Vermont Ave., NW
Washington, D.C., 20005

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FLUID DYNAMICS INCORPORATED

Circle No. 15 on Subscriber Service Card

An Expensive Failure

PARIS

U.S. FIRMS were in an uncomfortable and unexpected position last week at the Paris Air Show. Present in greater numbers and with more costly exhibits than at any time in the past, they discovered themselves outmaneuvered on the international scene—all too plainly tagged by the Soviet Union with the old "merchants of death" label.

The blame for this lies squarely on the doorstep of the Administration. With a complete lack of sensitivity to the recent American image that has been built up abroad by the situations in Viet Nam and the Dominican Republic, the U.S. government decided to create entirely a military impression at the Le Bourget display.

The reason for such a decision can, at this point, only be subject to speculation. But it is no secret that Secretary of Defense Robert S. McNamara and his Deputy Assistant Secretary for foreign sales, Henry J. Kuss, Jr., have been driving hard to build up the U.S. military export market.

We would be the last to suggest that this is not a sound idea. The laments from the British about high-powered U.S. salesmanship stealing markets which the United Kingdom long has regarded as personal property are petty. This is a British sorehead attitude because someone is beating them at their own game.

Our complaint is not with the U.S. hard sell in the foreign armaments field. It lies entirely with the complete lack of intelligence—in both the literal and political sense—which left the U.S. out on a limb at Le Bourget.

This year's show was the biggest and most important of the 26 which have been held. The Administration, and most specifically those in charge of U.S. government participation, badly bungled the planning job.

The initial fault was in the decision to emphasize military, at the cost of civilian, accomplishment. There was no National Aeronautics and Space Administration exhibit at Le Bourget. This was a bad decision originally. On the heels of the worldwide enthusiasm over the *Gemini 4* flight, it was incredible that there was no *Mercury, Gemini* or *Apollo* capsule on display.

With photographs of Ed White's space walk dominating the front pages of every paper in Europe —the London *Daily Express* called one "the most amazing picture in the history of mankind"—Europeans at the show could only express astonishment to their American friends at the U.S. failure to follow up at Paris.

While the U.S. displayed the McDonnell F-4, Northrop F-5, Lockheed C-141, Grumman Mohawk, Bell Iroquois, North American Vigilante, Douglas A-4, General Dynamics B-58. Martin *Titan II*, General Dynamics *Atlas* and a panoply of other military hardware, the Soviet Union turned up with a full array of commercial airliners and helicopters.

With U.S. space accomplishment far less evident than that of, say, Sweden, the Russians produced Yuri Gagarin, a *Vostok* spacecraft, and an interesting exhibit of space gear. Firmly established in their own building, the Soviets had only to count the crowds to size up their triumph.

On the day the U.S. showed its military muscle, with a flyover of 16 Navy F-8's on a round trip from a carrier in the Mediterranean, the Soviet Union unveiled a shiny model of its 121-passenger Tupolev-144 supersonic transport.

Coming on the heels of recent international events the result of all this was not favorable to the U.S. The Russians appeared as peaceful salesmen. The U.S. image at Paris was that of an uncouth military giant.

We should make it clear again that our complaint is not against the extent of the impressive military display at Paris but its exclusivity. What ever happened to the pitch about the peaceful uses of space? Where was the man with sense enough to realize that the Paris Air Show, a showcase and marketplace for the nations of the world, provided an outstanding opportunity to cap off the McDivitt-White *Gemini 4* flight with a smashing triumphal appearance at Le Bourget, the very field where Lindbergh captured the hearts of France, Europe and the world? Why was there no NASA display at Paris?

THE PITY OF IT is that, despite the U.S. emphasis on armaments, two military aircraft most likely to attract foreign sales had to be kept at home because of test schedules—the F-111 and the Convair Charger. The same problem kept the Douglas DC-9 from the show.

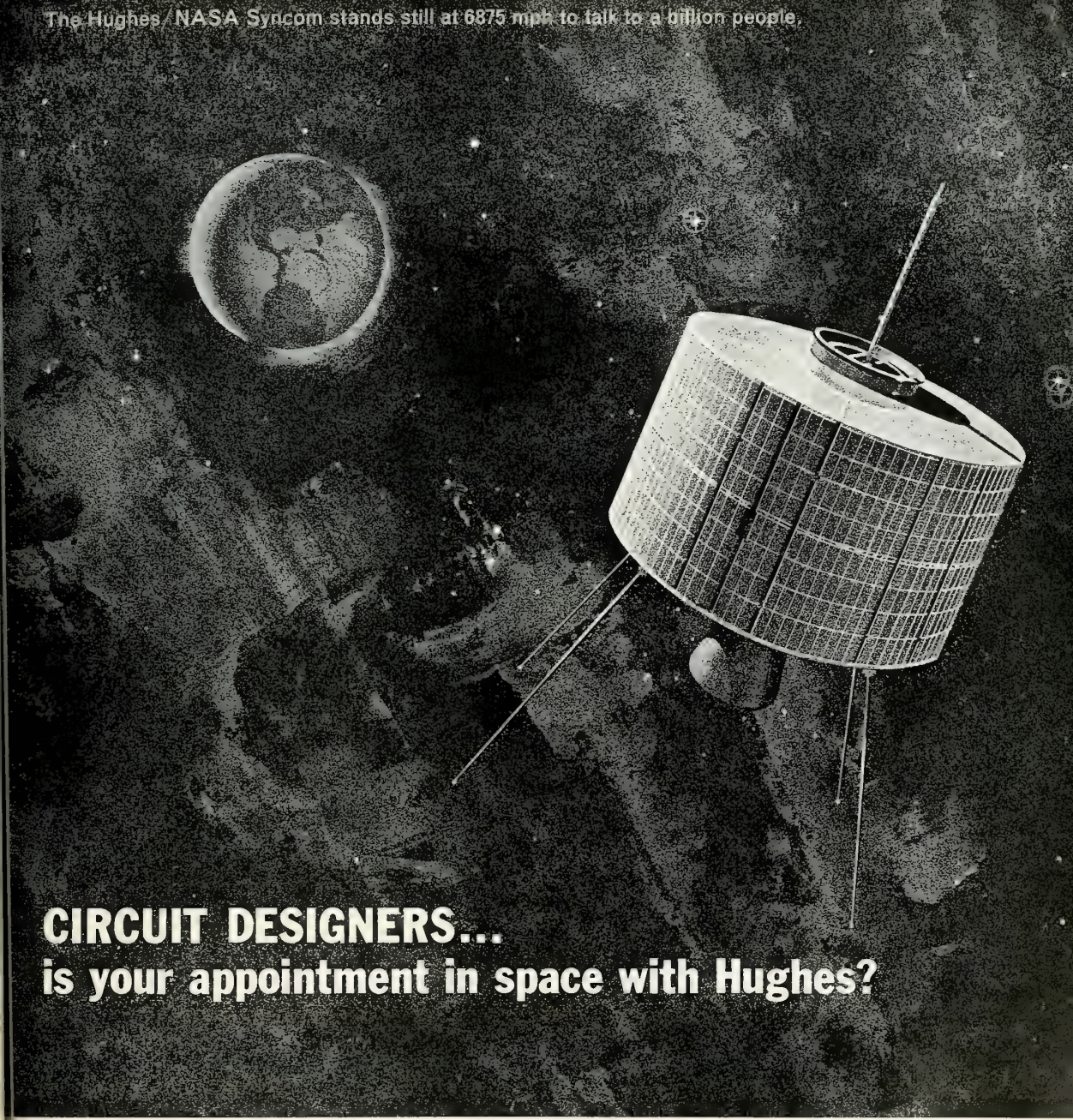
Raytheon exhibited the *Hawk* but was unable to show the *Sparrow* because of military restrictions. All in all, U.S. missile salesmen found the European market far from bullish. A number of countries are developing effective weapons of their own and a number are disillusioned with the support received for weapons already purchased.

An effective propaganda triumph in the space field might have offset some of this feeling. Instead, the absence of a U.S. space exhibit was made conspicuous not only by the considerable Russian space effort but also by the attention devoted to space by the French, Germans, and even the British.

It was evident that France has set out on a determined effort to carve out an impressive space role. This was seen not only in boosters and satellites but also in telemetry, radars, simulators and all the other hardware which make up a space program. The Germans showed some impressive work on the third stage of the *ELDO* booster as well as some interesting satellite projects. The United Kingdom played down its own role somewhat in favor of emphasis on cooperation but did not neglect the space field.

Amidst all this, the U.S. blunder was wincingly evident. Long faces at the U.S. Embassy attested to this. There was hope at week's end of some slight repair (the *GT-4* film of White's walk was flown in for showing), but lacking a personal appearance of the two U.S. astronauts, the U.S. was badly outmaneuvered at Paris by the Soviet Union.

William J. Coughlin



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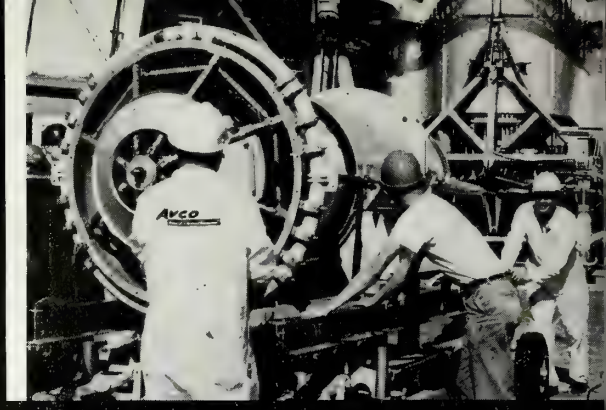

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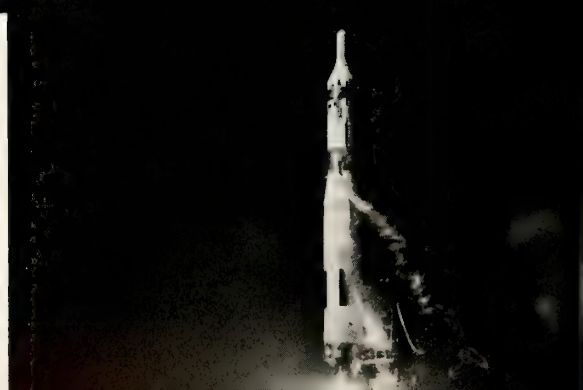

JUNE 28, 1965

missiles and rockets

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Structural Mechanics Engineers—Engineers to establish the technology needed by the structural Analysis & Loads & Dynamics Sections in the design of aircraft, missiles, spacecraft & other vehicles. Duties include Determination of dynamic loads & response, structural analysis & synthesis techniques for conventional & advanced structures, improved design criteria based on statistical or structure reliability, static & fatigue strength design allowables new type of construction for improved strength—weight ratios; determination of critical thermal-design conditions; advanced analysis techniques for vibration & flutter, gust response, buffeting & unsteady aerodynamics; MS or PhD in AE, CE, ME or Applied Mechanics or equivalent exp & education is prerequisite. Both Junior, Senior positions available.

Stress Analysis Engineers—Structures Engineers to participate in the design of aircraft, missiles, spacecraft & other vehicles. Duties include: participation in the arrangement & optimization of the structure, providing the designers with internal loads, & conducting the structural analyses to substantiate the design. A working knowledge of the basic methods of stress analysis including the fields of plates & shells, redundant structures & fatigue strengths is desired. BS or MS in AE, CE, ME or Applied Mechanics or equiv exp & education is prerequisite. Both Junior & Senior positions available.

Thermal-Structural Engineers—M.S. in Engineering with specialization in heat-transfer or equivalent experience. Will perform structural temperature calculations and participate in the thermal-structural design of aerospace vehicles and their heat-protection systems.

Dynamic Test Engineers—BS in Engineering including course in vibration. Knowledge of instrumentation (accelerometers, velocity pick-ups, oscilloscopes, oscillographs, etc.) and vibration excitation (shaker systems is desirable). Ability to perform dynamic analysis in support of test work is required. Duties involve: vehicle vibration surveys; solution of in-flight vibration problems including electronics malfunction and structural fatigue; vibration and shock qualification testing; vibration and flutter testing of dynamic models,

(Additional opportunities on following page)

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(Continued from previous page)

Armament Design Engineers—BS in AE or ME with 5-years experience in Armament & Pyrotechnic Design & Installattion. Work includes design, selection & installation of Armament & Pyrotechnic subsystems & components in aircraft, missiles, ships & space vehicles. Must be capable of analysis & design of structural, mechanical & ballistic components such as ejector racks, propellant actuated devices, guns, linear shaped charges, rocket & missile launchers.

Flight Controls Engineers—BS in ME, CE or AE, experienced in Control Systems & Mechanical Linkages and familiar with aircraft design practices needed for development & design of systems & components for aerospace & marine vehicles.

Alighting Gear Design Engineers—BS in ME, CE or AE with minimum of 5 years experience in mechanical systems design & familiar with aircraft design practices. Background should cover some of the following areas: Mechanical linkages & their motion analysis; structural design of mechanical components; determination of power requirements & selection of power supplies; shock attenuation devices; wheels, brakes, anti-skid, & steering devices; & interpretation of military specifications. Duties: Assist in the formation of aircraft alighting gear system concept & in the detail design of the over-all system & its components.

Fluid Power Design Engineers—BS in ME, CE or AE with a sound background in the design, development & installation of fluid power components & systems in military aircraft. Must be thoroughly familiar with all controlling military design requirements & specifications.

Environmental Control and Life Support Test Engineers—Experienced in system testing-development, qualification, functional preflight. Should be capable of writing test plans and reports. Must be familiar with instrumentation requirements, laboratory equipment. Manned testing experience desirable.

Environmental Control & Life Support Systems Engineers—BS in Engineering or equivalent experience with background in Environmental and/or Life Support Systems for space and aircraft applications. Scope of work covers all phases from proposal preparation to final system check-out including analysis, design, development, testing, installation, liaison with Manufacturing Dept., Vendors and customers.

Crew Station Designers—BS in Engineering or a minimum of 5 years design experience. Capable in cockpit or spacecraft design including generating own drawings of Crew Station layout. Familiarity with Geometry-Display and control arrangements with supporting knowledge of Human Factors principals and task analysis associated with man-machine relationships is essential. Pilot experience desired but not mandatory.

Rocket Propulsion Engineers—Engineering degree plus several years experience with liquid rockets. Involves challenging duties in the area of steady-state, transient, and mal-function performance analysis as applied to manned space vehicles. Both junior and senior positions available.

Reaction Control System Engineer—Technical specialist to perform analysis of small pulsed rocket engines and pressure fed propellant systems. A firm background in liquid rocket engines desirable.

Senior Thermodynamicist—Advanced degree with minimum of 5 years experience performing heat transfer analysis. Specific opportunities in aerodynamic and re-entry heating, structural temperature determination and heat transfer phenomena in propulsion systems.

Heat Transfer Engineer—BSME to work on thermal design of space electronic systems. Must be able to perform detailed analyses of electronic equipment cooling requirements and direct necessary thermal test programs.

Thermal Control Engineer—Engineer with experience in handling space vehicle temperature control system analysis. Should have background in radiative heat exchange and thermal coatings as applied to passive and active temperature control systems.

Gas Dynamics Engineer—BS in AE or ME with applicable experience, to be responsible for one or more of the following: Internal Aerodynamics, Ducted Fans, VTOL, Thrust Deflection Systems, Compressible Fluid Flow, Shock Wave and Boundary Layer Theory, Inlet, Nozzle and Exhaust System Flow Analysis; Method of Characteristics; Windtunnel and Duct Lab Testing.

Carrier Suitability System Engineers—BS or advanced degree with minimum of 1 year experience in establishing operational compatibility of a given weapon system with ship facilities and ship installations. Operational experience is highly desirable. Will establish high density and/or mixed compliment aircraft spotting characteristics, investigate aircraft and ordnance handling, and verify the compatibility of related support equipment and facilities with the aircraft carriers concerned and/or other operational sites and vehicles.

NOTE: Positions also available in the above areas to February or June '65 Engineering Graduates

Use the attached inquiry form to arrange a mutually convenient interview.

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For your convenience and to facilitate your inquiry, please use this form. It will enable the professional staff at Grumman Aircraft to evaluate your background and experience and arrange for a mutually convenient personal interview. All inquiries will be held in strictest confidence. Enclose in an envelope and send to Mr. P. M. Van Putten, Manager, Engineering Employment, Dept. GR 86, Grumman Aircraft Engineering Corp., Bethpage, L.I., N.Y.

NAME_____

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CITY & STATE_____ TELEPHONE_____

NEAREST MAJOR CITY (IF APPLICABLE)_____

COLLEGE GRADUATE: YES___ NO___

Degree	Subject	Year

Major Specialty_____ Yrs.___ Other Specialty_____ Yrs.___

Applying for position(in)(of)_____

Background and experience (Brief resume of experience, recent history of employment. If available, attach prepared resume.)

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY

Volume 16, Number 26 June 28, 1965

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THE COVER

Air Force Titan III-C, which developed more than 2.4 million pounds of thrust at liftoff June 18, rises from launch pad at Cape Kennedy. The powerful launch vehicle's first flight was virtually flawless. Eleven more development launches remain. *See story, p. 14.*

JUNE 28 HEADLINES

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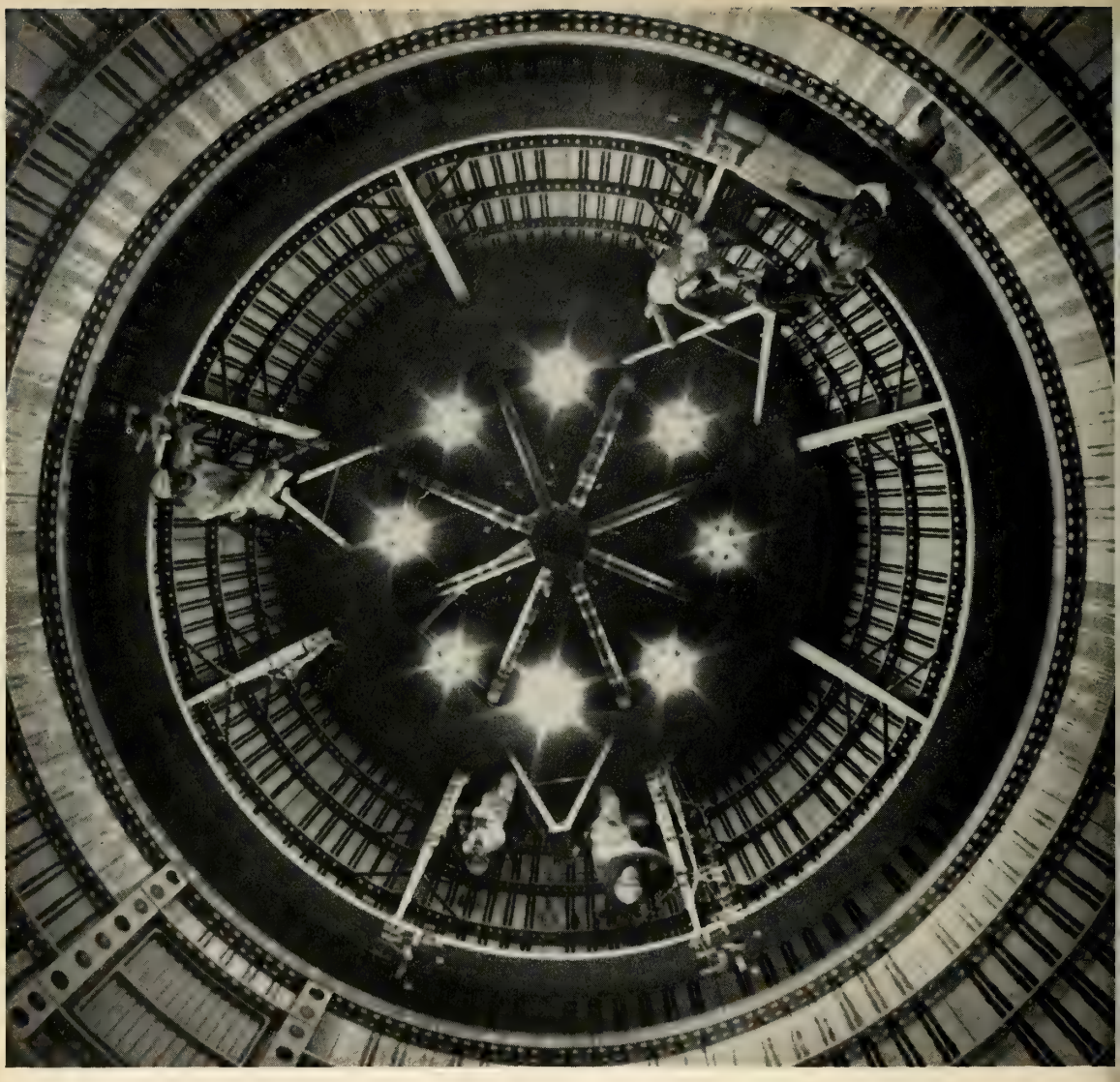

Careers on the move in **manned space programs**

The photo above shows a section of the Douglas S-IVB stage of *Saturn* being readied for strains beyond any it will undergo in space.

Mr. M. F. Snodgrass, Douglas Missile & Space Systems Division, 2700 Ocean Park Boulevard, Santa Monica, California.
I am interested in career opportunities at Douglas MSSD.

NAME _____

ADDRESS _____

_____

Degree(s): _____

Field(s): _____

Specialty(ies): _____

U.S. Citizen: Yes ☐ No ☐

This program is typical of the missile and unmanned and manned space system programs at Douglas that have created immediate openings for engineers and scientists to work on important programs for this decade and the next.

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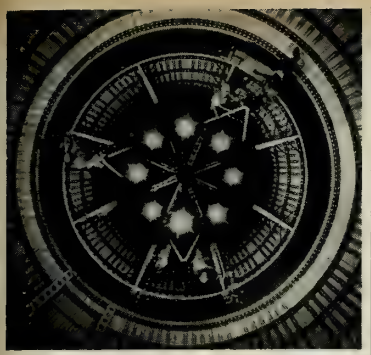

Immediate openings for engineers and scientists:

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Orbital mechanics, mission analysis and trajectory analysis.

Manned Spacecraft Programs
Operations Analysis, Systems Engineering, Digital (Monte Carlo) Simulations, & Computer Programming.

Cryogenics Engineers
Analysis design of cryogenic propellant rocket propulsion subsystems.

Physicists, Chemists, Engineers
Fundamental research in field of ultra-high vacuum adhesion.

Solid Propellant Systems Engineers
Rocket motor and ballistics and motor optimization trade-off studies.

Aero/Thermo
Heat transfer and fluid mechanics for thermal analysis of booster and space vehicle systems.

Life Support and Environmental Control
Design analysis integration development and or Fortran experience.

Electrical Engineers
Automatic Test Systems. Requires experience analyzing design requirements to control product quality.

Structures
Structural elements, thermal protection systems, pressure vessels. Conceive, design components/systems.

Propulsion Design
Set design criteria and evaluate solid and liquid systems.

Advanced Propulsion systems
Set preliminary design criteria for solid and liquid systems.

Control Systems Engineers
Design, analysis: Nike-Zeus, Thor.

Ground Support Equipment
Design & test ground support equipment. Design electrical systems.

Chemist/Chemical Engineer
Design, develop: Electrochemical, life support devices and pre-treatment techniques for waste fluids.

Chemist—Fuel Cells
Applied electrode technology catalysis, or electrochemical technology.

Mathematician
PhD. Help make new, special purpose computers/programs.

Battery Technologists
Design, fabricate, test: High energy density batteries, electrodes, separators, cases, seals, components.

letters

JMSPO Clarified

To the Editor:

Your May 31 issue carried an article ("DOD Steps Up Weather Satellite Work," p. 16) on the new office of which I am a part, the Joint Meteorological Satellite Program Office (JMSPO). The writer, Donald L. Zylstra, did us a great service by clearly defining the relationship of the Defense Dept. to NASA and the U.S. Weather Bureau in the field of meteorological satellites. This relationship is often hazy in the minds of those who are not directly concerned with this line of endeavor, and we're confident that your article will help clarify this situation.

Peter E. Romo
Colonel, USAF
Chief, Joint Meteorological Satellite Program Office
Directorate of Operational Requirements and Development Plans
DCS/Research and Development
Headquarters, USAF
Washington, D.C.

'MPT' for 'mpt'

To the Editor:

Why is it that there is always some wise guy with poison pen poised ready to attack anyone who dares suggest a solution to an apparent problem?

In this case the wise guy is C. Dean Hermansen (Letters, June 7, p. 7), whose unwarranted sarcasm regarding Mr. William A. Koch's suggestion to use "mpt" as an abbreviation for million pounds thrust left me completely disgusted.

It would behoove Mr. Hermansen, and other wet blankets like him, to offer some constructive comments and join Mr. Koch in a sincere attempt to assist readers and writers alike in finding an acceptable abbreviation for a combination of words which have become a technical cliché of the industry and our time.

May I also add, for Mr. Hermansen's enlightenment, that capital "M" also is an accepted abbreviation for the following (per MIL-STD-12B):

Bending Moment, Magnaflux, Manila (in relation to rope), Mega (10^{6}), Metacenter, Meter, Milli (10^{-3}), Mode, Model (for use in military nomenclature).

I feel quite certain that Mr. Koch would not object to using capital letters (MPT) in lieu of lower-case (mpt); perhaps if presented this way (his suggested abbreviation) will be removed from the "Tom, Dick and Harry's personal hieroglyphics" category.

W. W. Ferguson
Pompton Lakes, N.J.

NASA Managers

To the Editor:

I was flabbergasted by a statement in your article, "New Center Will Produce Prototype Hardware as Well as 'Paper R&D'," (M/R, May 31, p. 24). The article stated, "ERC has already come up with two procedures unique to the space agency's research work. They are: Laboratory chiefs will not simply monitor industry and university contracts that are awarded; they will manage them. This means that they will work along with the contractor during the time the work is performed rather than sitting back waiting for it to be completed and a final report submitted."

I would like to point out that this procedure is not an ERC innovation, and there are a number of industrial and university researchers whose contracts have been *managed* by me and other people in my organization who can attest to this. In fact, on occasion we have received complaints from some of our contractors for our active participation in the research effort.

Furthermore, this *management* practice is not limited to our organization only. While I cannot speak for all the rest of the Marshall Space Flight Center and other NASA centers, I do know of many other organizations within MSFC and NASA which *manage* research contracts "rather than sit back waiting for it to be completed and a final report submitted."

Good Grief!

Judson A. Lovingood
Deputy Chief, Astrodynamics and Guidance Theory Division
Marshall Space Flight Center
Huntsville, Ala.

Bombs of Yesteryear

To the Editor:

In a letter in M/R June 14 (p. 6) Mr. Lawrence E. Truppi mentioned the Grand Slam (22,000 lbs.) and Tallboy (12,000 lbs.) bombs the British used on hard targets and bridges in the last year of World War II .

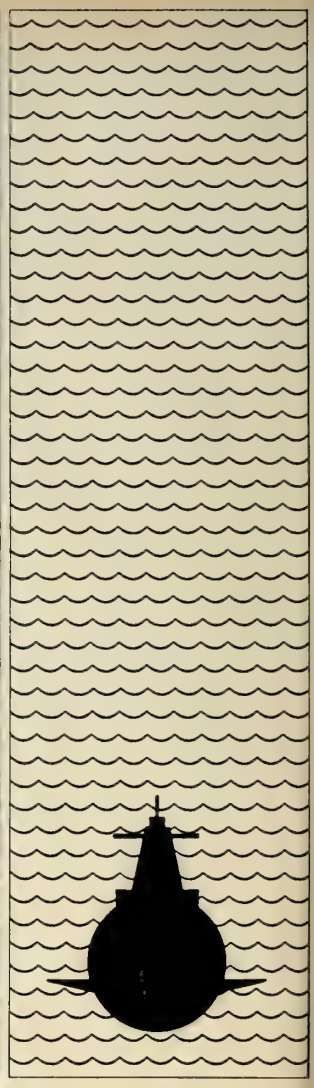
Ever been down to Aberdeen Proving Ground, Md.? There is a 42,600-lb. general-purpose bomb designed similar to the British items, only larger, standing on its nose down by the Museum area. I think it is still listed in the ammo catalogues, along with some other large-size hole makers.

Doubt if any of the stuff we fly in Viet Nam would have space for it, as those with internal stowage are mostly for atomic stuff, and those with wing racks would be a little lopsided if they could get it off the ground.

Of course, if we had the sabotage capability of the Reds, we could get an engineer platoon in on the ground with a few hundred pounds of Composition C4 and make a much cheaper and more precise mess of things.

John P. Conlon
(former aviation ordnanceman)
Newark, Ohio

P.S. That 42,600 job stood for years in the open, and postcards of it were sold in town. Years later someone found it was Confidential and clearance had never been made on it.



"He maketh the deep to boil like a pot..."

This was ASW, Old Testament version (*Job* 41:31). ASW, 20th century Navy style, is something else. It is thousands of men, planes, ships and subs—tied together by a staggering array of electronics. It is long patrol flights, long months on station, lonely watches. It is everything—fused into a potent, single-purpose defense system. From the Arctic to the Antarctic—in, on and over the seven seas. TRW provides systems integration and test support for this vast and vital Navy mission. The Anti-Submarine Warfare responsibilities assigned to TRW create openings in: Operations Analysis, Engineering Analysis, Systems Analysis, Program Analysis, Test Project Engineering, Test Evaluation Engineering, Test Planning Engineering and Configuration Control Engineering.

TRW's participation in 90% of all U.S. space launches has created openings in: Theoretical Physics, Systems Engineering, Radar Systems, Experimental Physics, Applied Mathematics, Space Communications, Space Physics, Antennas and Microwaves, Inertial Guidance, Analog Computers, Solid State Physics, Computer Design, Telecommunications, Digital Computers, Guidance and Navigation, Electromechanical Devices, Engineering Mechanics, Weapons Systems, Applied Aerodynamics and Propulsion Systems. For TRW openings in Los Angeles, San Bernardino, California, Houston, Cape Kennedy, and Washington, D.C., write TRW Professional Placement, One Space Park, Dept. M-6, Redondo Beach, Calif. TRW is an equal opportunity employer.

TRW SYSTEMS

Formerly TRW Space Technology Laboratories

The Countdown

WASHINGTON

UTC Studying Smaller Strap-ons for Titan III-X

Air Force has awarded United Technology Center a $300,000 project-definition-phase contract for a study of one-, two-, and three-segment versions of UTC's 120-in. *Titan III-C* solid-propellant motors in the non-man-rated *Titan III-X* development program. Strap-ons currently used for man-rated *Titan III-C* are five-segment.

Limit Likely on Titan Payload Hammerheading

Technical studies made in connection with the *Titan III* program indicate that future payloads for the system can be successfully hammerheaded to accommodate 156-in. diameters. Investigation of hammerheading up to 260-in. diameters continues, but 156 inches is considered about the upper limit for the system unless there are major alterations in booster vehicle structure.

Titan Seen Offering Dramatic Savings

AF development officers in the *Titan III* project are highly optimistic about the effect the new multi-purpose booster will have on the cost per pound of launchings—particularly in its non-man-rated *Titan III-X* version. Experience to date indicates that the *III-X* will be able to launch payloads in a variety of simple missions for as little as $500 per pound, contrasting with the present cost of $1,000 per pound.

Two Centers, Two Contractors for AES

It now appears almost certain that two NASA centers—Marshall Space Flight Center and Manned Spacecraft Center—will share direction of payload integration work for the *Apollo Extension System*. This also will mean selection of two separate industrial contractors, one to work for each center. Plans are still to be approved by NASA headquarters, but this is expected in the near future. RFP's for four to six months of preliminary definition will be issued shortly.

Early Bird Officially for Hire

Comsat Corp. will begin commercial use of the *Early Bird* satellite this week under temporary approval of its tariff by the Federal Communications Commission (see p. 24). While approving the tariff last week, the FCC also ordered an investigation into the "propriety" of the tariff schedule in general and an expedited hearing on certain provisions. The corporation was given special temporary authorization to provide TV transmission directly to the three major broadcast networks. All initial revenues from satellite communications, and refunds by Comsat to the common carriers, were placed in "deferred credit" accounts to be used only with FCC authorization.

Bollerud New Space Medicine Deputy Head

Col. Jack Bollerud has been named deputy director for space medicine in NASA's Office of Manned Space Flight. He formerly was chief of the Science Div. of the Directorate of Science and Technology at AF Headquarters.

Major Hearings Loom on Capitol Hill

Important dates in Congress this week include a meeting Monday of the Senate Independent Offices Appropriations subcommittee considering the NASA appropriations bill. Consideration by the full Appropriations Committee is scheduled for Wednesday. On Thursday, Comptroller General Joseph Campbell, head of the General Accounting Office (GAO), will testify before the House Military Government Operations subcommittee. He'll answer charges brought by DOD and defense contractors that GAO has overstepped its rightful role in contract auditing.

Senate Blocks Clause on Aerospace Corp.

The Senate has ruled out a clause in the military authorization legislation passed by the House which would prohibit Aerospace Corp. from constructing additional facilities or acquiring any real property without Congress' consent. If the House wants to persist in this recommendation, the Senate Armed Services Committee indicated, it should write such a clause in a bill concerning research and development matters.

INDUSTRY

Strike Threat in Industry Wage Demands

Heads of unions representing employees of virtually all big missile/space companies are warning of possible strikes if the workers are not given substantial wage increases and other benefits that may add up to more than 50 cents an hour. President Walter P. Reuther of the United Auto Workers calls aerospace workers "second-class industrial citizens" who are being required to "subsidize the defense and space programs by substandard wages and fringe benefits." President Al J. Hayes of the International Assn. of Machinists indicated that the unions' goal is a settlement yielding about the same increases as that signed by the auto agreement last year—about 54 cents an hour spread over a three-year period. Another official said the average hourly pay in the industry is now about $2.95 an hour—16 cents an hour less than in other major industries. Industry-wide bargaining is to begin next month.

Moon Seen Rich in Organic Matter

Experiments carried out at U.C.L.A. indicate it is highly likely that organic material exists on the Moon "in great profusion," Prof. Willard S. Libby told the Air Force Office of Scientific Research annual seminar at Cloudcroft, N.M. He said ionizing radiation on simple hydrocarbons produces dramatic amounts of branch hydrocarbons similar to lubricating oils. He attributed this to positive ion chemistry and said that intense solar radiation would mean that all the original primeval dust in the solar system was covered with this material. It is found in the oldest sedimentary rock in ordinary chondrites and can be expected on the Moon, he said.

INTERNATIONAL

Rubis Rockets Satellite in Suborbital Shot

Three *Rubis* rockets, built by SEREB of France, were successfully fired recently at the Hammaguir missile site in the Sahara. First two were part of the test program for the second stage of the rocket, which will be the third stage of France's *Diamant* satellite launcher. Third was used to put an *D-1* satellite into a suborbital path reaching an altitude of above 1,200 miles. *Rubis* is now operational and is expected to be available soon on a commercial basis.

The Missile/Space Week

Mariner Pix To Be Withheld

NASA and Jet Propulsion Laboratory officials report that it may be months before researchers release the better quality photographs taken from *Mariner IV* during its Mars encounter July 14.

JPL Director Dr. William Pickering said researchers had decided to release only the first few photographs, perhaps only three, to the press within a few days after the encounter and that these were likely to be "crude" because they would be obtained from only one tape recorder transmission. The first pictures are not expected to be those from closest to Mars nor from the best angle.

There was no immediate official explanation for the decision not to release the best photos of the historic flight to the public on an as-soon-as-possible basis. However, one spokesman said that "agreement with the scientists assigned to study the photographs gives them a proprietary right to scientific information, including the photographs."

Titan Upstages Saturn-Centaur

NASA contentions that *Saturn IB* with a *Centaur* upper stage "will do the same jobs contemplated for *Titan III*" are immediately countered these days by Air Force arguments pointing to a complete *Titan III-C* in being.

The Air Force emphasizes serious *Centaur* deficiencies yet to be overcome. With its high-energy cryogenic fuels, *Centaur* continues to pose an insulation problem for long stays in space; *Centaur* is still faced with a 2,750-lb. compression weight limitation, unless it is beefed up structurally; and its present guidance life of 18 minutes would have to be lengthened several times to make it the equal of the guidance in the *Titan III* transtage. Also, still not resolved is the very considerable problem of restarting a cryogenic system consistently at orbital altitudes.

Although the Air Force obviously isn't keen on the possibility, it continues to mention *Centaur* as a possible third stage in its current development of the non-man-rated *Titan III-X*.

DOD development people believe that in *Titan III-A*, *-C*, and *X* they will have the best workhorse booster system in existence. It would span the entire spectrum from *Thor-Agena* payloads to the capacity for placing 44,000 lbs. in near-Earth orbit (using two three-segment 156-in. strap-ons). But military space chiefs see little likelihood that there will be any rush on NASA's part to supply payloads for *Titan III*.

Saturn Titanium Use May Grow

General Dynamics/Convair will study the application of titanium to large rocket structures under a $397,000 contract from NASA's Marshall Space Flight Center. The *Saturn V* first stage will be considered for purposes of the study.

The impetus for the move came from the successful development of roll diffusion bonding of titanium. In this process, the titanium is sealed in steel as elements of the desired structure. The structure then is "grown" together and formed at high temperatures with roll pressures applied in the directions necessary to give the correct configuration.

Combinations of metallurgical reactions and physical interactions induced during the processing make it possible to knock away the steel after cooling—leaving the finished titanium alloy structure.

The development is expected to substantially influence the design and performance of future space launch vehicles as well as the supersonic transport and advanced military aircraft. A preliminary study covering the 33-ft.-dia. thrust section for the *S-IC* stage showed weight savings in excess of 20% through titanium substitution.

Finger Gets New AEC Post

Harold B. Finger will direct the newly formed Division of Space Nuclear Systems of the Atomic Energy Commission. Purpose of the division is to better coordinate the space-related R&D work of the AEC.

Finger will also continue to head the joint AEC-NASA Space Nuclear Propulsion Office and a new Space Electric Power Office to administer space reactor and isotope power systems work.

SRAM-Type Motor Fired

A three-pulse, dual-thrust-level solid propellant motor with performance patterned after the potential requirements for *SRAM* propulsion passed a complete firing test at Lockheed Propulsion Co.

Tested in a horizontal bay at Lockheed's Potrero production and test facility, the 18-in.-dia. motor burned for three varied time periods as downtime between pulses stretched the total action to four minutes.

Firing of the three pulses was controlled manually from an instrumentation bunker. The boost grain was center-perforated to give larger burning surfaces and a thrust level more than three times that of the end-burning sustainer and dash grains.

Modified Agenas Negotiated

NASA is negotiating with Lockheed Missiles & Space Co. to modify seven *Agena-D* second-stage boosters. Total cost of the contract will exceed $13 million.

The space agency is also discussing a contract with Rocketdyne Div. of North American Aviation, Inc., for 22 H-1 rocket engines for use on the *Saturn IB*. Cost of the engines and supporting services will exceed $6 million.

Fifth Apollo Abort Planned

The space agency will conduct its fifth *Apollo* launch escape test at White Sands Missile Range, N.M., no earlier than June 29.

The off-the-pad abort test will use a dummy *Apollo* Command Module to simulate abort from ground level. The *Apollo* launch escape system will provide 155,000 lbs. of thrust and carry the launch escape vehicle nearly 5,000 ft. above range.

Shots of the Week

NASA initiated a new research rocket, the *Aerobee 350*, June 18 with a firing from Wallops Island, Va. The *350* uses a *Nike* booster and a cluster of four, 4,100-lb.-thrust *Aerobee 150* engines. The first shot carried a 370-lb. payload to an altitude of 235 mi. The rocket is designed primarily for carrying loads on the order of 150 lbs. to altitudes of 300 mi.

- Poland launched its first meteorological rocket on June 16. The two-stage vehicle was 2.5 meters long and reached an altitude of 37,000 meters.
- The Army successfully fired its in-house-developed version of the new *Medium Anti-tank Weapon (MAW)* at Redstone Arsenal, Ala., June 17, with the McDonnell wire-guided candidate for the same mis-

sion having been fired at Redstone a little more than a week earlier.

• Army missilemen of the 1st Battalion, 81st Artillery successfully fired a *Pershing* tactical missile from a site at Gilson Butte, Utah, into a target area in the White Sands Missile Range, N.M. on June 16.

• Two air-to-air missiles, presumably either *Sidewinders* or *Sparrows*, brought down two North Vietnamese MIG-17 fighters June 17 some 40 mi. south of Hanoi. The missiles were launched from Navy F-4 fighters.

• *Titan III-A*, after being postponed late in the countdown on June 16, scored a resounding success on June 17 (see p. 14).

• Canada's *Black Brant* research rocket underwent its first two launches successfully on June 12 and 18 from Ft. Churchill, Manitoba.

• The Air Force resumed tests of the *Athena* re-entry program with two shots June 18. Launches were from Green River, Utah, into White Sands Missile Range, N.M. One was termed a complete success; the other 80% successful.

• NASA test pilot John B. McKay flew the *X-15* rocket plane to an altitude of 158,000 ft. on June 22 to test star tracking cameras.

• On June 23 the Air Force launched a *Minuteman* ICBM from Vandenberg AFB, Calif., toward a target 5,000 mi. down the Western Test Range.

Tiros X Set for Launch

Launch of the *Tiros X* weather satellite is scheduled from Cape Kennedy no earlier than June 29, NASA has announced.

A *Delta* booster will place the 280-lb. satellite into a Sun-synchronous, near-polar orbit. It will contain two ½-in. vidicon cameras and be capable of photographing up to 80% of the Earth every day.

Tiros X is the first satellite in the series to be funded by the U.S. Weather Bureau. *Tiros VII, VIII,* and *IX* are still operating.

F-1 Marks 1,000th Firing

The 1,000th firing of the F-1 rocket engine has been conducted at NASA's Rocket Engine Test Site at Edwards, Calif. The North American Aviation engine was operated at full thrust of 1,500,000 lbs. for 165 seconds.

The total firings involved tests with 58 different engines. One engine was tested 24 times for an accumulated firing time of 3,153 seconds, the company said.

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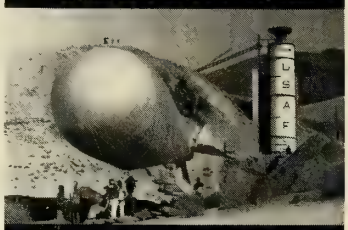

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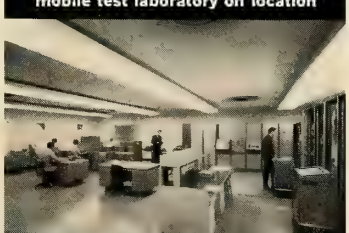

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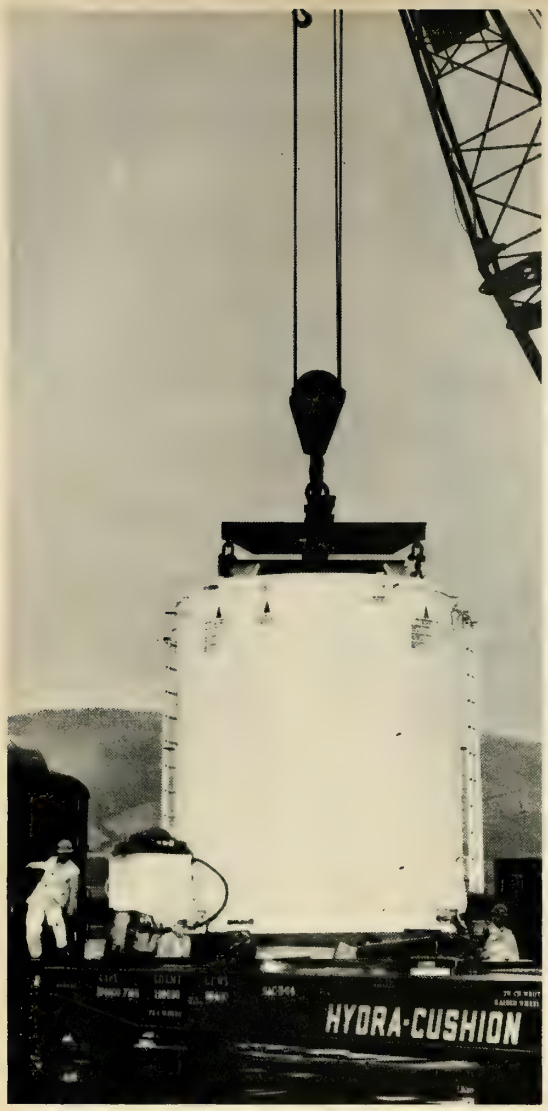
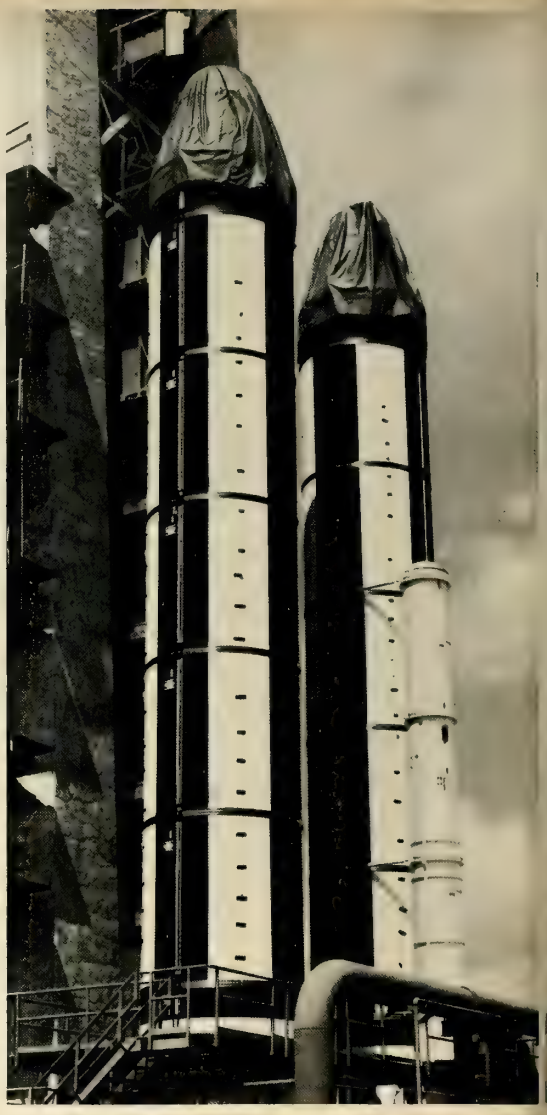


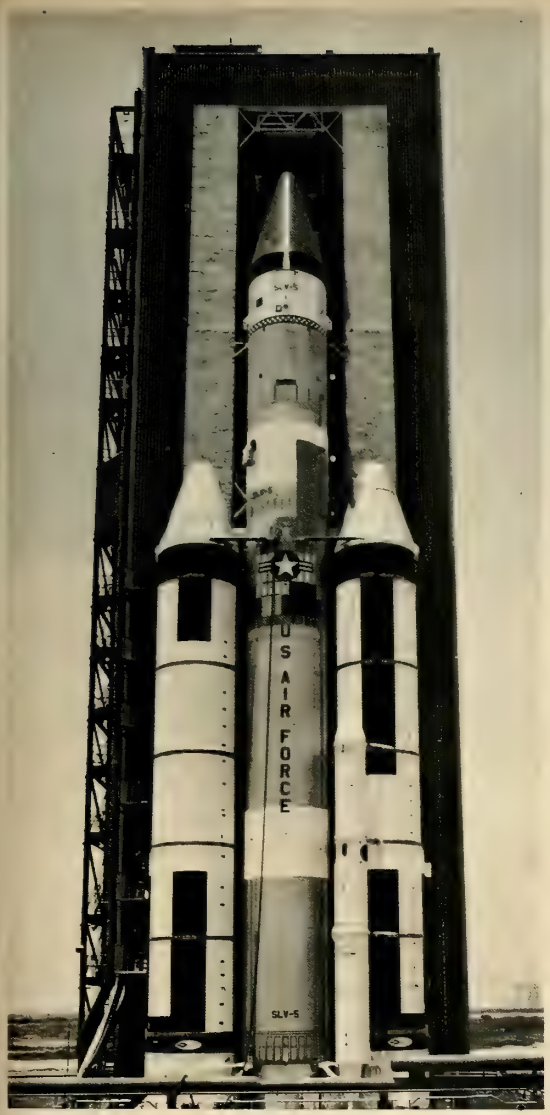
ONE FOR THE MONEY

America's newest and most powerful flight-ready motor for space programs is a big penny-pincher. This single building-block solid propellant segment weighs 40 tons, yet it is easy to handle, safe to store, and economical to build. The five-segment 120″ diameter boosters in USAF's Titan IIIC mean low-cost high reliability for a variety of missions from here on out.



TWO FOR THE SHOW

The world watched as the core vehicle was mated with two of UTC's million-pound-thrust booster stage motors at launch pad 40 in Cape Kennedy's ITL (Integrate-Transfer-Launch) complex. The segments which made up the motors had been cast and cured at our Development Center in California and delivered to the pad on hydra-cushion flat cars. A unique joint developed within United Aircraft Corporation linked them solidly together.



THREE TO GET READY

Solid rocket motors are essentially simple, so checkout for the booster stage of Titan IIIC was virtually complete when thrust vector control plumbing was installed on the assembled boosters. Final checkout on the liquid-propelled core vehicle and all interface systems proceeded during countdown. At the moment of lift-off, the booster stage lent over 2-million pounds of thrust to the enormous space launch vehicle. The head start this gives to the core vehicle is tremendous. It's like moving Cape Kennedy *25 miles straight up.*

ALL SYSTEMS GO!

A bare two minutes after ignition, the solid rocket boosters have burned up their 400 tons of propellant. At this point, the core vehicle can begin its mission.

It's a very significant milestone in rocket technology: **Big solids are here.** And from here we can go almost anywhere we want. Bigger payloads won't need new systems; all you have to do is add more segments to the boosters, or more boosters to the core vehicle. The dream has become a reality. All systems are go.

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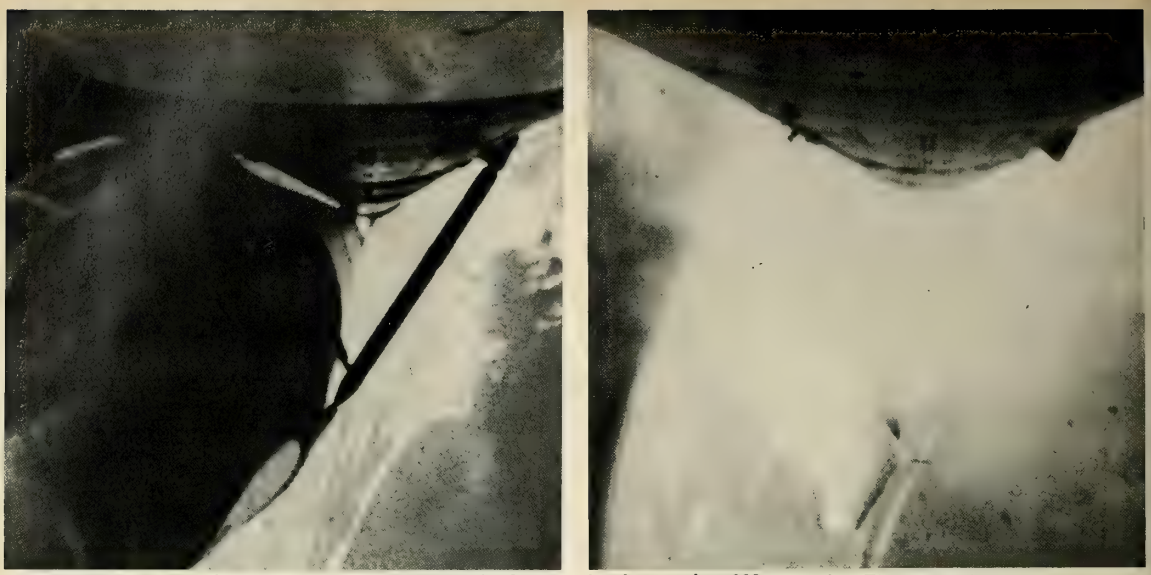


IGNITION of Titan III first stage and separation of solid boosters in photos taken 108 secs. after Titan III-C launch.

Titan III-C Also Managerial Success

Officials expect to complete development at cost within 5% of original estimate; strap-on potential for Saturn noted

THE LAUNCHING of *Titan III-C (SLV-5)* achieved more than a virtually flawless technical performance. It drew new attention to the program's extraordinary managerial and fiscal accomplishments.

The *Titan III-C* management team is now confident that it will complete its development work with total expenditures kept within plus or minus 5% of the $800,000,000 cost estimated in April, 1962. By contrast, all other military development programs of this magnitude have exceeded original cost estimates by 100% or more.

Following the June 18 launch, Brig. Gen. Joseph S. Bleymaier, Air Force Space Systems Div. deputy commander for manned systems, noted that *Titan III-C* development had proceeded through three fiscal years of budgeting "without the Air Force asking for a single extra dollar" in support.

Spurred by the maiden performance of the vehicle, biggest ever launched, the AF/industry 624A program team is striving for a duplicate success in the next attempt, scheduled for sometime in September.

With at least 11 launches remaining in the ambitious test program, the *Titan III-C* management will be under constant pressure until the vehicle reaches fully operational status.

● **Cost apportioned**—A breakdown of the $800-million effort shows funding divided as follows among four major contractors:

The Martin Co.—airframe, system assembly and integration—$300,000,000; United Technology Center—development of solid motors, including both test and flight motors—$200,000,000; Aerojet-General Corp.—liquid propulsion systems, including aerospace ground equipment—$60,000,000; AC Spark Plug Div. of General Motors—guidance systems, including aerospace ground equipment—$40,000,000.

The remaining $200,000,000 covers transportation, propellants, housekeeping support at the Air Force Eastern Test Range, Phase I definition studies, and test facilities.

Cost-plus-incentive-fee (CPIF) contracting has been employed throughout the entire program with the exception of 15% of the value of the contracts awarded UTC. In the latter case, the Government and contractor agreed that exact characteristics of some items of aerospace ground equipment could not be defined well enough to warrant the CPIF approach. Incentive provisions in developers' and manufacturers' contracts embrace a range of 2½-12½%, with an average incentive figure of about 7½%. A total of $1.1 million in incentive award possibilities rode on successful contractor performance during the first *Titan III-C* flight test alone.

Air Force development chiefs already are privately convinced that successes in the *Titan III* program to date will spell the end of any need for using liquid cryogenic fuels in the first stages of future all-purpose space booster systems. They cite an estimated quantity production cost of $12.8 million per copy for *Titan III-C*, compared with $22 million for NASA's *Saturn IB*—and further note that the $800-million investment in *Titan III-C* development is a mere fraction of the funds invested in *Saturn IB*, which still lacks a satisfactory third stage, while the Transtage is already performing successfully in *Titan III-C*.

● **Solid success**—Major question answered by the first launch was whether two massive solid boosters could be used in combination as the largest boost assembly ever to leave a launch pad.

Preliminary data indicated the 120-in.-dia. solid strap-on boosters hit predicted velocity at burnout on the nose, then cleanly separated from the core vehicle some 28 mi. over the Atlantic.

The entire system was programmed to inject the 29,285-lb. payload assembly at 25,583 fps. Actual speed was 25,584 fps. UTC's solids burned hotter than

FILM from ocean-recovered pod cameras shows clean separation and firing of small thrustors at either end of solids.

planned, and one second shorter—resulting in the accurate velocity.

Preliminary orbit figures were: apogee, 102.5 n. mi.; perigee, 95 mi.; period, 88.16 minutes.

The unqualified success serves to sharpen the entire strap-on solids question. In the Stage Zero configuration the solids can increase the *Saturn IB* payload ability to 80,000 lbs. in a low Earth orbit.

More important, the mating of NASA's primary booster family with these solids could extend their useful life considerably beyond current projections from a cost-effectiveness viewpoint.

The current *Titan III-C* program itself provides a substantial number of vehicle versions for the Air Force. Number of segments can be increased from the five used in the opening shot to seven.

These units would hit peak thrusts of more than 1.4 million lbs. each, and permit launching full-design payloads for the *Manned Orbiting Laboratory* from the Western Test Range. Thus, *MOL* could be developed in flights from the Eastern Test Range using the five-segment booster, then be deployed at full operational weight at WTR.

Conversely, reducing the number of segments provides thrust augmentation to the basic *Titan III* core vehicle and spreads a low-orbit payload range from 9,000 to 15,000 lbs. in economical increments.

Addition of four five-segment 120-in. motors to a *Saturn*-type vehicle as either the booster or Stage Zero might result in a quick and inexpensive way to launch payloads of 40,000-240,000 lbs.

● **Upper stage arrives**—The *Titan* storable liquid core vehicle suddenly qualified as a relatively high-energy upper stage during the launch—completing its cycle from ICBM through *Gemini* to altitude ignition.

The core first stage had a predicted thrust of 474,000 lbs. at altitude ignition, but there is some evidence that actual thrust may have been somewhat higher. The bootstrap, double-thrust chamber powerplant generates about 430,000 lbs. thrust as a primary booster.

Major subassembles of the Aerojet-General engine (LR87-AJ-9) include the two thrust chambers with an exit-to-throat area ratio of 8 to 1 and engine bells of 43-in.-dia.

There are two gas generators, two turbines, four turbopumps and autogenous pressurization components. The first stage—and all other liquid stages—use nitrogen tetroxide and Aerozene 50 (a mixture of hydrazine and unsymmetrical dimethyl hydrazine) as the oxidizer and fuel. The propellants are storable and ignite hypergolically. ■

Major Subcontractors to UTC on 120-in. Motor Program

Wright Aeronautical Div., Curtiss-Wright Corp.—motor cases.

Rocket Motor Case Dept., Westinghouse Electric Corp.—motor cases.

Allison Div., General Motors.—thrust vector control tanks.

H. I. Thompson Fiber Glass Co. (HITCO)—nozzles.

Structures Division, TRW Electromechanical Div., TRW Inc.—nozzles.

Rohr Corp.—motor case insulation.

Lockheed California Co.—thrust vector control manifold.

Military Electronics Div., Ling-Temco-Vought, Inc.—thrust vector control injectant valves and pitch and yaw controls.

Cadillac Gage Co.—thrust vector control hydraulic power supply.

Tyce Engineering Corp.—thrust termination system.

Jet Research Center, Inc.—thrust termination and destruct system.

Hamilton Standard Div., United Aircraft Corp.—checkout equipment for electrical systems.

Sikorsky Aircraft Div., and Corporate Systems Center, both of United Aircraft Corp.—solid motor attach structures.

Valley Metallurgical Processing Co.—spherical aluminum powder.

Dow Chemical Co.—D.E.R. 332 epoxy resin.

Allied Chemical Corp., Plastics Div.—Nadic (R) methyl anhydride.

Yardney Electric Corp.—Silvercell silver-zinc battery for TVC control.

Astronauts Recoup Space Prestige

But USSR profits by lack of space hardware exhibits from U.S.; French show great progress; Part II of M/R report on Paris Show

by Michael Getler

PARIS—A last-minute appearance by the *Gemini 4* astronauts prevented a total propaganda defeat for the United States at the 26th Annual International Salon of Aeronautics and Space.

U.S. prestige was also boosted to some degree by news of the successful first launch of *Titan III-C* at Cape Kennedy June 18, two days before the close of the show held at Le Bourget airport.

President Lyndon B. Johnson ordered Astronauts James A. McDivitt and Edward H. White II flown to Paris on the same day. They were accompanied by Vice President Hubert H. Humphrey, NASA Administrator James E. Webb, and Charles W. Mathews, *Gemini* program manager at Manned Spacecraft Center.

The astronauts drew enthusiastic crowds wherever they went at the airport. An attempt to arrange a formal meeting with Yuri Gagarin, Russia's first orbiting cosmonaut, was thwarted when Soviet officials said Gagarin's schedule was too busy. But the three managed to get together at a lunch pavilion (see photo).

The visit put the space race in somewhat better perspective.

● **NASA no-show**—Nevertheless, the U.S. was badly upstaged by the Russians, who scored a propaganda coup at very little cost—principally because NASA just wasn't there to compete.

The Russian display included nothing more than a full-scale *Vostok* spacecraft, some separate exhibits of individual systems such as the ejection seat, and Cosmonaut Gagarin. But the USSR pavilion drew more crowds than any other.

There was no NASA participation in the Paris show, which is the world's largest trade show of any kind. With the exception of some very imaginative and complete U.S. manufacturers' displays, America came off looking like a mere arms merchant, which happens to coincide with a notion currently popular in Europe.

The major U.S. hardware displays involved aging *Atlas* and *Titan* ICBM's, and military aircraft. The so-called "Aerospace USA" exhibit was devoid of interest and sparsely attended.

● **French off ground**—The French commitment to, and investment in, space science and exploration was very obvious at Le Bourget. As one top French space scientist told M/R, "we have nothing startling, but at least things now exist."

This year's show made it plainly visible that the space program in France is beginning to evolve into the myriad items of hardware necessary to support such an effort. New space chambers, attitude system test stands, large filament-wound rocket-motor cases, refined electronic subsystems, improved laboratory devices, and operational ground tracking stations were all in evidence.

Among the most significant French displays was a just-completed Sud-Aviation glass-filament-wound solid-motor rocket case, the largest ever built in Europe. It holds 28 tons of propellant, is 2 meters wide and 560 centimeters long, and has about 15-cubic-meter volume. The unit, which makes use of the fabrication techniques Sud developed for the third stage of the *Diamant* satellite launch vehicle, was built to expand the technology in this field and also to study the possibilities for new engines with 30-ton thrust levels, according to Sud engineers. Built with company funds, it reportedly represents only about 2% of the total propellant weight.

Also displayed was a model of the new French satellite tracking system, Diane, developed for CNES by Compagnie Française Thomson-Houston. The two-station tracking system is now

ASTRONAUTS White (center) and McDivitt (right) join hands with Cosmonaut Gagarin at informal meeting during Paris Show. Looking on is Vice President Humphrey.

in operation (M/R, June 7, p. 9) but "not completely operational," according to French scientists.

The stations have tracked U.S. satellites and have performed in accordance with predictions which indicate considerable capability. They have already been selected to be integrated in the European Space Research Organization (ESRO) tracking net. Four additional telemetry and command stations comprising the balance of the French network will be operational by 1966.

The Diane system employs interferometry techniques using two baselines, a longer one for fine measurements and a shorter one for removing phase ambiguities. Thirteen antennas are used, eight to form a polar and equatorial array and five folded dipoles for ambiguity removal.

These stations reportedly are able to provide angular measurement accuracies on the order of 100 microradians, which corresponds to less than 100 meters for a satellite at 1,000-km distance. Key to the systems performance is said to be the use of synchronous demodulators which allow demodulation of very-low-level signals.

In other new electronics developments, the French displayed a newly developed CO_2 laser operating in the 10-micron regime. In experimental form it reportedly has achieved efficiencies to 4% and a 4-watt CW output. Engineers at the Societé Anonyme de Telecommunications, the group that developed the laser, say this is a record output.

A new sun-tracker, with an accuracy expected to be better than 10 minutes of arc and also better than the design specifications, was also displayed. This unit, developed by SINTRA, will be flown for the first time aboard a *Dragon* rocket in September.

● **More rockets**—The already sizeable stable of French sounding rockets is also likely to grow soon, as the CNES ponders a decision on expanding the *Dragon* family to provide about a 200-lb. payload capability.

The new system would be called *Eridan,* something which has already apparently been introduced into the French military rocket family (M/R, June 14, p. 9). *Eridan* involves a larger-diameter *Dragon* first stage, and another *Dragon* as the second stage. Sud Aviation is working on a CNES feasibility study, and the outlook for development is reportedly favorable.

France will launch the first scientific payload aboard its *Rubis* rocket in September. *Rubis,* which has had a successful series of trial firings, was used to put a *D-1* test satellite into suborbital flight for its first CNES mission on June 3. The rocket is expected to be used for a wide variety of assignments by CNES.

The French *Tacite* rocket received its first test in a new role on June 15, when it was used to loft an ONERA experiment intended to make IR contrast measurements between the Earth and the surrounding atmosphere. The experiment uses a new type of long-wavelength detector.

● **Satellites**—Models of the French *D-1* satellite now slated to be launched aboard a *Diamant* vehicle from the Hammaguir site in Algeria in the first quarter of 1966 were on exhibition, as was the *FR-1,* which will be the first French satellite in orbit. The latter is slated to be launched in December of this year, using a U.S. *Scout* booster, at Western Test Range.

The *D-2,* the first purely scientific French satellite, is just beginning to take shape. Mock-ups of both the structure and payload areas were displayed for the first time at Le Bourget. This satellite is to be launched in early 1968 aboard a *Diamant* and will be the first to lift off from the new site in French Guiana.

Possibly coming before *D-2* will be the French *"Eole"* project, aimed at satellite monitoring of balloons for atmospheric measurements. CNES is now investigating possible NASA participation.

Also shown for the first time was the new SEPR-produced high-energy upper stage, which utilizes liquid hydrogen and liquid oxygen and produces 3,300 lbs. of thrust from each of four engines, using just one turbopump with the four chambers. The thrust level is fixed but can be time-varied, according to SEPR, and the engine can be restarted twice. An advanced model in development will use more refined regenerative cooling and a fluid actuator in the gimbal nozzle to replace electronics.

● **Germans, too**—Also reflected here this year was the steady growth of German space activities, though the production funding has yet to match the general enthusiasm.

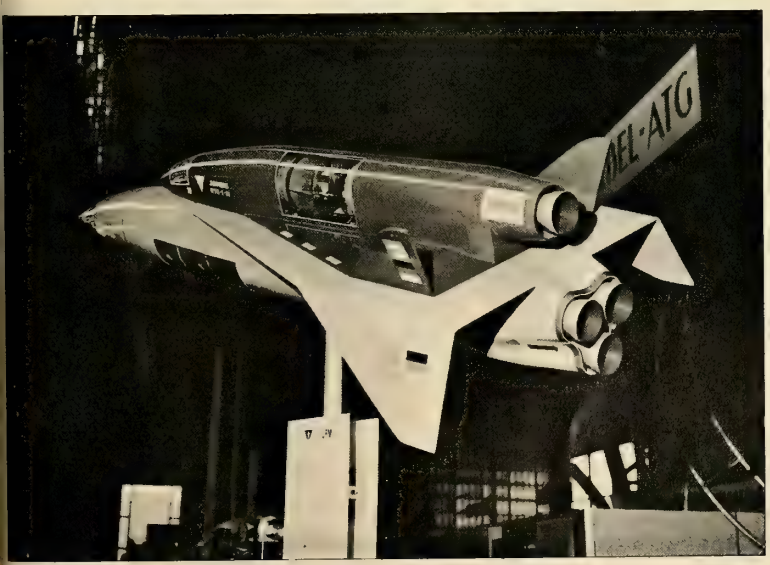
Engineers from Boelkow GmbH showed models of both satellites of the proposed *625-A* series and a more sophisticated *625-B* research satellite, which would use a paraboloidal plastic mirror as a solar concentrator for space power.

The German government has not yet given approval to any of the programs in terms of major hardware development, but a decision of the first one, *625-A1,* is expected this fall. This satellite would make major use of U.S. components and be launched by a *Scout* into a near-polar orbit in 1967. Study of the *A2* satellite was completed in May, but experiments have not yet been firmly defined and no contract or launch dates have been set.

The plastic mirror system, which Boelkow has developed for the *625-B* program to support a very large power demand, attracted considerable attention here. The system is folded during launch and deployed in orbit, using a gas pressurization system to deploy it and a polyurethane foam on the back to rigidize the shape. The mirror is 22 ft. in diameter and focuses energy to heat a mercury working medium. The solar-turboelectric system reportedly will provide 2.5 kilowatts.

The mirror is built up to 25-micron thickness with several separate layers of polyester film and a vapor-evaporated aluminum reflecting layer. ■

JUNKERS displayed this model of spaceplane it is studying under contract awarded by West German government. Both stages of ship would be piloted.



SRAM Funding Slashed by House

Appropriations Committee stipulates that MOL money cannot be diverted; minority members hit lag in new weapons effort

DEVELOPMENT OF the Air Force's *Short-Range Attack Missile (SRAM)* has been dealt a damaging blow in House action on the Defense Appropriations Bill.

The House voted June 23 to cut $30.7 million in Fiscal Year 1966 funding for the program, leaving only $7 million to support the Administration request for development funds for the next year. The vote came after the House Appropriations Committee had recommended such a fund reduction in the program.

In other action on the bill, the Appropriations Committee made clear its strong support for the Air Force *Manned Orbiting Laboratory (MOL)* by stipulating that the $150 million earmarked for full-scale *MOL* development shall be available only for this purpose. In its report accompanying the bill, the committee stated that it "does not want the managers of other development programs to attempt to divert funds from this program to other programs."

Total procurement funds voted in the bill amounted to $11.390 billion, $21.7 million below the budget request and $2 billion less than the funds appropriated for FY '65. Research, development, test and evaluation funds recommended by the committee were $6.594 billion, $114.3 million less than the requested amount, and $145.9 million more than FY '65 appropriations.

The bill for the first time was accompanied by additional remarks by Republican members of the Defense subcommittee—Reps. Glenard P. Lipscomb (Calif.), Melvin R. Laird (Wis.), and William E. Minshall (Ohio). The minority trio voiced strong feelings that the administration is lagging in its development of advanced weapons systems, and called for immediate increased effort on *MOL* and anti-submarine warfare. They also criticized DOD for its "rigid and often narrow attitude toward advanced developments."

- **Procurement**—Funds for Air Force missile procurement were granted as requested at $796.1 million, which is $933.9 million below FY '65 funds.

The Army request was cut by $17.3 million, including a $7.2-million cut in electronics and communications programs and a $10-million cut as a result of program changes that have occurred since the formulation of budget estimates. Total amount recommended for Army equipment and missiles was $1.2 billion, which is $450.5 million below FY '65 figures.

Navy aircraft and missiles were recommended to be funded at $2.272 billion, $7.3 million below the budget estimates. This includes cuts in procurement of F-4 and F-111B aircraft. In commenting on the F-111B, the committee pointed out that two "serious problems" have emerged: the weight of the aircraft and development difficulties with the *Phoenix* missile system for the Navy version.

Although the committee said it felt continued funding of the F-111 program is essential, it directed that no funds be programmed for "hard tooling" or similar production equipment in FY '66 until ample notice and information supporting such action has been made available to the Appropriations and Armed Services Committees of the Congress.

The Marine Corps received appropriations of $43.8 million, as requested. This figure is $119.1 million less than that received by the Corps in FY '65.

The committee commended DOD for some improvement in management and procurement practices in the communications and electronics field, but noted that more could be made. To that end, a reduction of $26.8 million was made in the request of $926.6 million.

- **RDT&E**—The Air Force received $3.103 billion in research, development, test and evaluation money. Reductions totalled $43.9 million (as in the authorization bill). These were recommended applied as follows: military sciences, $10.2 million; XB-70, $10 million, which the committee said could be cut without changing the planned fiscal year flight test program; and *SRAM*, $30.7 million.

In making the *SRAM* cut, the report stated that the program has been delayed, and the project definition phase will not be completed until after FY '66. The $5 million available in FY '65, together with funds remaining for FY '66, will support the revised program objectives for the year, the committee indicated.

The committee also set aside $24 million of new obligational authority to be used only for advanced manned strategic aircraft development.

Army RDT&E was cut by $17 million in the military sciences estimate, $2 million for federal contract research centers, $6.6 million for R&D funds for a classified installation, and $6 million in the "other equipment" category. Total Army RDT&E funded was $1.406 billion.

The Navy's military sciences program was cut by $19.7 million. An additional $10 million was deleted from the *Advanced Surface Missile System (ASMS)* (M/R, June 14, p. 12), "an area of great difficulty and disappointment for both the Navy and Army." The cut left only $2 million in the program for FY '66. ■

SNAP Systems Feel Budget Knife

THE SNAP 10A and SNAP 50 programs of the Atomic Energy Commission were cut further in the Public Works Appropriations bill, approved by the House last week.

Only $7 million was left in the SNAP 10A program by the Appropriations Committee, which deleted $6 million that had been budgeted for a second test flight. The committee said its action was "pending the firming up of requirements for an additional test."

The SNAP 50 program was cut an additional $2 million, bringing to $12 million the trimming it has suffered at the hands of Congress this session.

The Joint Atomic Energy Committee had cut the program by $10 million in the authorization bill, stating that "objectives have been dropped or cut back and schedules have been extended to the point that project-type objects and goals no longer exist for this work."

Technical Countdown

MATERIALS

Ruthenium Aids in Cooling Hydrogen

Use of the catalyst ruthenium in cooling hydrogen fuels may cut the weight of future air-breathing, high-speed propulsion systems by as much as 1,500 lbs. The catalyst is a development of the Air Force's Research and Technology Command through its Aero Propulsion Lab at Wright-Patterson AFB. Hydrogen is used both as a fuel and as a coolant in critical engine and aircraft components and the use of ruthenium causes an instantaneous conversion in the hydrogen so that its temperature is lowered and it absorbs heat faster. This heat absorption speed means that equipment can be designed with fewer heat-sink or cooling components. The catalyst essentially converts para-hydrogen to ortho-hydrogen, a higher energy state. Researched by Engelhard Industries, the catalyst consists of particles of an inert support material coated with pure ruthenium. It is about 60 times as effective as the best catalyst previously available. Liquid hydrogen is produced as 100% para-hydrogen. It is easier to ship and store as a liquid in this state. The higher-energy ortho form tends to boil off due to the natural conversion to the para form in the liquid state. The ruthenium-catalyzed conversion proceeds endothermically.

Aerojet Aims to Synthesize Helium Difluoride

Scientists at Aerojet-General Nucleonics are developing a technique to synthesize helium difluoride. Once the existence of a stable helium difluoride has been established and its characteristics explored, the energy-rich compound may find applications in rocket fuels. A side benefit is that if AGN scientists can establish a chemically bonded helium, it may also exist bound in the Earth's crust—thus opening a new source to offset the rapidly diminishing world supply of helium. The technique being developed involves placing tritium between fluorine atoms in a transparent lattice containing a bifluoride ion. The radioactive tritium will decay into helium while the solid lattice will hold the helium atom in place between fluorine atoms. This is the optimum position for the formation of a chemical bond. The work is being funded by the Office of Naval Research.

Impact Ripples Studied for Meteoroid Protection

Investigations are now being conducted by scientists at Technical Operations Research into the wave-like surface deformations in metals caused by the impact of very high-speed particles. The researchers have found that thin metal targets behave like a fluid when struck by objects travelling in excess of 15,000 fps. The metal undergoes a jetting action into the space ahead of the impact point. When this occurs, an instability is created, resulting in the formation of a wavy or rippled surface. Metallurgical analysis has shown that the wave structure is identical to the bonding obtained by explosive welding. If two plates are used as a target in the impact studies, they become permanently bonded because the jetting action aids in diffusion and the rippled surface increases the area of contact and interlock.

PROPULSION

Lockheed Unveils New Steering Concept

A series of subscale movable nozzles will be built and tested by Lockheed Propulsion Co. under an Air Force contract totalling $346,000. The tests will involve a new steering concept—called "Lockseal"—developed by the firm. The approach eliminates the heavy, complex and expensive components required by current gimballing nozzle designs in large solid rockets. The Lockseal connects a contemporary submerged nozzle to the rocket case through an elastomeric seal rather than by using a rigid structure with sliding seals. Hydraulic actuators are used to move the nozzle through any axis. The seal is protected from the internal rocket motor combustion by a flexible insulating barrier. The contract from the Rocket Propulsion Lab. of Air Force Systems Command's Research and Technology Div. calls for the production and test firing of four nozzles in various sizes.

Multi-Pulse Rocket Tests Completed

The feasibility demonstration of Aerojet-General's prime offering in the *SRAM* competition—a multi-pulse solid rocket—ended with the test firing of a materials evaluation motor. The rocket concept consists of three grains separated by frangible thermal barriers, each containing an igniter system and measuring only fractions of an inch thick. The booster grain is an internal-burning, star port design, while the other grains are end-burning. The thermal barriers have held grain temperature to 200°F adjacent to the combustion of a grain at more than 6,000°F.

ELECTRONICS

New Electric Power Inversion Method Proposed

An industrial-university-government research team suggests using inverters in parallel redundant systems to handle electrical power inversion in spacecraft and satellites. The four experts detailed the system before the IEEE meeting in Houston last week. The team—two from Westinghouse's Aerospace Electrical Div., one from NASA's Lewis Research Center and one from Ohio Northern University—said that they had successfully demonstrated, through operational tests, the techniques and circuits they described. The researchers claimed the approach can provide the high power and high reliability mandatory in space systems with relatively high efficiency and little or no weight problems.

Lockheed Patents Radar Augmentor

An optical device which increases both the effective range and detection ability of radar has been patented by Lockheed Electronics Co. The optical correlator improves radar performance by stretching out short bursts of radar energy into the long pulses needed for distant targets. When the signal returns, the correlator compresses the pulse back to its original, short form. The device also holds promising potential in multi-channel communications, and may be a key to more efficient and economical industrial process control. The correlator can be used as a tool to explore electronic signal characteristics.

SPACE MEDICINE

Air Force Tests Toothpaste

The Air Force has developed a toothpaste that can be swallowed for use on short-term spaceflights. Named Astro-9, it has a glycerine base to avoid adding calcium to the diet, which would complicate metabolic readings. It was tested in the five recent 30-day simulated space flights at the School of Aerospace Medicine. For long-duration spaceflights, however, Air Force doctors are investigating paint-on dentifrices.

GT-5 Will Test Rendezvous System

Transponder test assembly will replace Agena vehicle in first in-orbit evaluation of radar equipment; details of flight plan

by Charles D. LaFond

FIRST ORBITAL testing of the *Gemini/Agena* rendezvous radar system will be in the *Gemini-Titan 5 (GT-5)* mission now scheduled for late August.

The *Gemini 5* vehicle will carry the operational L-band radar interrogator, which includes an *Agena* command link. Replacing the *Agena* target vehicle, however, will be the mating transponder and blinker light system installed within the *Gemini* adapter ring. The transponder test assembly, called the Rendezvous Evaluation Pod (REP) will be ejected from the spacecraft after orbital injection and will be used to check out system performance and provide rendezvous maneuvering experience for the astronauts.

The transponder subsystem is identical to those that will be carried later in the *Agena* target vehicle.

In discussing the upcoming *GT-5* flight with MISSILES AND ROCKETS, Albert Wiegand, manager of Crew Station Integration for *Gemini* prime contractor McDonnell Aircraft Corp. in St. Louis, pointed out that the problems ahead now in the manned space program are concerned more with what the on-board equipment can do, rather than what man can do. Man, he said, has demonstrated his inherent flexibility and adaptability.

GT-5, he said, will serve as a test bed for several new systems, including the fuel-cell power supply and its associated instruments. The primary equipment test, however, will provide the first integrated testing of the rendezvous radar system with the onboard computer, inertial reference, displays, thrusters and the pilots.

Also, *GT-5* will carry an Air Force experimental radiometer package for passive tracking in several infrared ranges.

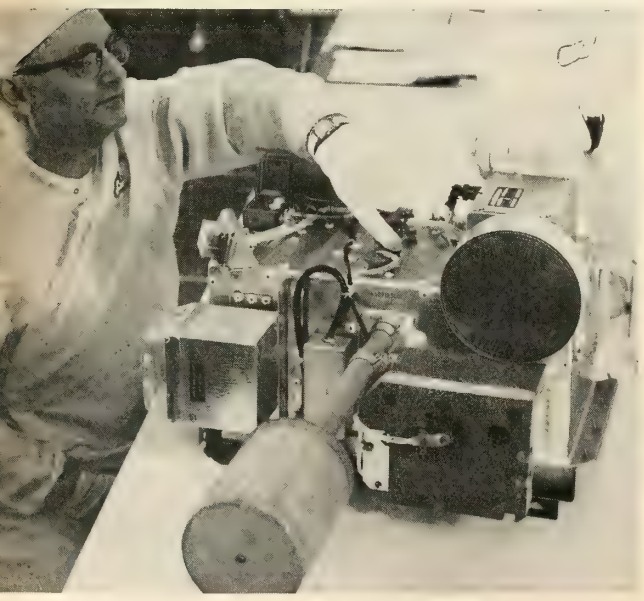
Considerable confidence in the radar system has been acquired in past months with the rendezvous and docking simulator developed by McDonnell and used by the astronauts at St. Louis and at the Manned Spacecraft Center in Houston.

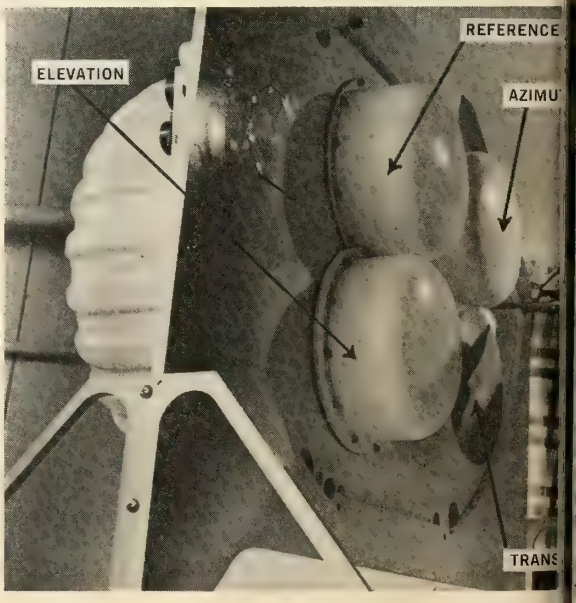
As a matter of fact, Wiegand emphasized, it was through use of the big simulator that the capability for docking was effectively proved.

Also, the radar system was extensively tested using an aircraft at White Sands Missile Range. In recent tests there, running several months, the transponder was carried in an Air Force T-33 jet, which was flown in carefully planned patterns at different altitudes and speeds. The radar interrogator was operated from a fixed ground installation and range and range-rate data were compared with those obtained from WSMR optical instrumentation.

● **Westinghouse radar**—In February, 1962, the Aerospace Division of Westinghouse Electric Corp. in Baltimore, Md., was awarded a cost-plus-incentive-

LEFT: Rendezvous Evaluation Pod, employing same transponder to be used in the Agena target vehicle, will be ejected by Gemini 5 for rendezvous system exercise. Developed by Westinghouse, the two opposed spiral antennas and dipole antenna (foreground) obviate tumble problems with radar transmission. RIGHT: Gemini-installed radar interrogator employs novel spiral receiving antenna design for obtaining accurate target range and angle measurements.





fee contract to develop and produce the complete *Gemini/Agena* rendezvous radar system. Total contract value is about $18 million, including nearly $2 million for spares and service.

The program calls for delivery of 16 radars: nine operational units, four production prototypes, and three engineering models. Seventeen transponders, including two for use in REP's, eleven command-link encoders, plus panel indicators and antennas comprise the remainder of the systems production order.

The *Gemini* radar subsystem weighs 73 lbs. and requires 80 watts input power. The transponder subsystem weighs 43 lbs. and requires a 69-watt input. Total weight of the REP, which includes antennas, transponder, boost regulator and power supply is 76 lbs.

• **GT-5 radar test**—The radar exercise will only duplicate the terminal phase of rendezvous as planned with the *Agena* during *GT-6* late this year. The distances will be scaled down by "a factor of three," according to Howard W. Tindall, Jr., of the Manned Spacecraft Center's Flight Operations Div.

It will start from that part of rendezvous when spacecraft radar "locks on" target. By that time, the plane changes and catch-up maneuvers will have been completed and the spacecraft will be in plane with the *Agena* and moving up on it, Tindall explained.

The pilots will first sight the flashing xenon lights, then point the rendezvous radar in the pod's direction. The L-band transponders on the REP will receive the signal from the radar and will respond to it with a fixed delay at a different frequency. Read-out onboard the spacecraft will be range, range rate, azimuth and elevation of the target.

Edgar C. Lineberry of the Flight Operations Division Rendezvous Analysis Branch told M/R how the maneuvers will be performed.

—The *Gemini-Titan 5* combination will be launched due east at a launch azimuth of 90 degrees into an 87 to 146-n.mi. or higher orbit with an inclination angle of 28.3 degrees;

—At a second apogee, the command pilot will make a translational "burn" using the Orbital Attitude Maneuvering System's (OAMS) thrusters in posigrade to raise the perigee 10-15 n.mi. Shortly afterward, he will yaw the spacecraft 90 degrees from his orbital path to eject the pod sideways from the adapter.

Lineberry estimates that the 5-fps velocity imparted from the spring release mechanism will move the pod slightly out of plane "about a half mile" at maximum distance, or anti-nodal point.

At the second perigee, the spacecraft will increase its distance from the pod with a 20-fps posigrade maneuver. This will raise the spacecraft's apogee about 11 n.mi.

• **Back to the pod**—As the spacecraft nears agopee (140 degrees of orbital travel later), the command pilot will move the spacecraft into a lower energy orbit. Burning the OAMS thrusters in retrograde (13 fps), he will start the spacecraft on a trajectory that will eventually return it toward the pod. However, before the effect of the OAMS burn takes place, the spacecraft will move to a 45-n.mi. separation point from the pod at mid-point of darkness on the night side of the orbit.

Up to this point, the spacecraft will have moved half way within the orbit of the pod. As the spacecraft nears perigee, the command pilot will make another burn (30 fps) in retrograde to move the spacecraft totally inside the orbit of the pod to set up the concentric rendezvous trajectory that will be used during *GT-6*. The altitude separation between orbits will be equidistant at approximately six nautical miles. The spacecraft, however, will be in the lower and faster moving orbit and will be gaining steadily on the pod.

The spacecraft will stay in this orbit for about 30 minutes while picking up the pod on radar, Lineberry said.

The terminal phase will begin about 130 degrees of orbital travel back from the rendezvous point, he explained.

There, with the spacecraft in a 27-degree pitch-up attitude, the pilot will begin to initiate thrust along the line of sight, also correcting for the small out-of-plane maneuver set up at pod ejection. The pod will be at mid-point of darkness on the night side of the orbit and against the star background.

The command pilot can stop the roll of motion sideways by sighting the target against the inertially-fixed star background, Lineberry said.

As the spacecraft moves up into the pod's orbit, the pilot will apply a braking thrust (16 fps) in retrograde and will close the distance between the two objects to within 50 ft. for the DOD-Air Force radiometer tracking experiment, Tindall said.

Finally, the spacecraft will fire the OAMS thrusters to move away from the pod and raise perigee to establish a seven-day orbital lifetime.

Several rendezvous attempts will be made during the *GT-5*, seven-day mission, including use of the radar only and use of pilot visual approach at close range. Rendezvous may also be attempted using ground radar data.

Depending on target orientation, Westinghouse engineers said, initial radar acquisition can be made at about 200-mi. range. Visual contact will be made from 10 to 20 mi., and full visual control will be possible at about one mile range. The radar, however, can be employed to zero range, they disclosed.

• **Radar details**—The radar will provide a pulsed, L-band signal with a peak output power of 1,150 watts. Average radar interrogator power is 0.3 watts, producing a 1-μsec. pulse with a 2-μsec. delay between pulses. The transponder signal, operating with a 100-mc frequency separation will employ a 1.8-watt average power and a 6-μsec. pulse.

Although no command link will be used with the REP exercise, it will be employed later with the *Agena* rendezvous. Transmission will be superimposed on the radar signals. Up to 62 digital commands will be available to adjust *Agena* position relative to *Gemini*.

The *Gemini* radar will employ three radome-covered spiral antennas for receiving and one spiral antenna for transmitting. The REP will carry two opposed transmit/receive spirals and one dipole will be illuminated and return its signal regardless of tumble.

• **Interferometric technique**—The *Gemini* spacecraft must locate the target vehicle, determine range and bearing, and then determine and make the necessary changes in position and orbital velocity for rendezvous and docking.

The particular radar design approach taken by Westinghouse was based in large part on three conditions: the target would be cooperative, relative closing velocities would be small, and dynamic inputs resulting from expected maneuvers would be very small.

Thus, the use of low-power, low-gain, wide beamwidth antennas could be used with both vehicle and considerable weight savings could be provided. A signal-to-noise ratio of at least 16 db is provided.

The system provides accurate digital angle and range data to the onboard computer from 180 n. mi. to 500 ft. Analog range and range-rate data are displayed from 300,000 to 20 ft.

The designed time delay between transponder reception of each radar pulse and retransmission of the translated signal permits the *Gemini* receiver to track the target to essentially zero-range, said Westinghouse. There is never an overlap of signal transmissions. Range determination is simply a measurement of round trip time minus the transponder delay.

An interferometric technique is used to determine angle measurements. Thus the difference in time of arrival of the *Gemini*-received signal between two spiral antennas is used with each compared against a common third antenna.

The three antennas are installed in the front of the spacecraft (see photo) in such a manner that the boresight axis is parallel to the roll axis. One pair (using the common or reference spiral) lies in the pitch plane, the other pair in the yaw plane. ■

Early Bird Going into Business

Schedule of charges likely to take effect regardless of running disputes over TV rates, channel allocations, ground stations

by Suzanne Montgomery

THE *EARLY BIRD* satellite is expected to make its debut in the field of commercial communications this week —despite the fact that it is still the subject of a series of controversies covering almost every phase of its operation.

As of the middle of last week, the Federal Communications Commission was expected to approve the tariff filed last month by the Communications Satellite Corp., despite objections from all three major television networks. A spokesman for the FCC indicated there was no reason to believe that Comsat's schedule of charges for use of the synchronous satellite would not automatically become effective June 27.

The commission also was expected to settle the allocation of *Early Bird's* 240 voice-grade channels among the common carriers. It was still not clear, however, what users of the satellite would have to pay in European fees. Also unsettled were questions of who will have ownership and control of future U.S. ground stations, who will be authorized to buy *Early Bird* service directly from Comsat, and whether Comsat has a corner on non-military communications satellite systems in the U.S.

The corporation wound up several weeks of experimental testing with *Early Bird*—including successful demonstrations of transmission of telegraphy, facsimile, telex, photographs and data. Use of the satellite for television programs was sharply cut back during the final days of the "free" testing period when European authorities imposed charges on use of ground stations.

Comsat also acquired a $5-million insurance policy for *Early Bird,* the U.S. Aviation Underwriters announced. Coverage includes liability should the satellite fall on a populated area, but not failure of its channels.

● **Networks protest**—Proposed charges for use of satellite circuits for television transmission brought forth strong objections to Comsat Corp. National Broadcasting Co., Columbia Broadcasting System and American Broadcasting Co. filed separate protests with the FCC against the "unreasonably" high rates set for broadcasters.

According to network petitions, the proposed tariff would discriminate against broadcasters and "preclude" television usage of the satellite system except for "the most unusual occasions." Calculations presented by NBC showed that charges for circuits used for television transmission during peak telephone hours would be approximately 10 times the amount charged for the same number of circuits used for other forms of communications.

Comsat officials would not accept the network's calculations and pointed out that rates for television transmission include an additional allowance for pre-empting the entire capability of the satellite. Because of present limitations of some of the European ground stations, additional circuits on *Early Bird* cannot be used for other forms of communications while television transmission is under way.

The networks also told the FCC that Comsat has set an "unduly long" minimum rate period of 30 minutes for television transmission, despite requests from broadcasters for a rate structure better fitted to a news operation.

The European rate schedule, which was to be announced late last week, is expected to heavily discourage television transmission during peak telephone hours. Although the minimum transmission time would be less, rates were likely to exceed those proposed by Comsat.

The European Broadcasting Union, representing television services in Western Europe, is reportedly protesting the levying of any tariffs by authorities without negotiations with the users. Both European and U.S. networks strongly objected to fees recently placed on use of the ground stations.

● **Limitations**—Of *Early Bird's* 240 two-way voice channels, only 120 will be available for use immediately. The FCC must allocate these between four U.S. common carriers who have requested to lease a total of 226 circuits. American Telephone & Telegraph Co. asked for permission to use 100 circuits; Western Union International, Inc., requested 55; ITT World Communications, 41; and RCA Communications, Inc., 30.

Circuits available are limited by lack of facilities at the European ground stations. Although Britain's Goonhilly Downs station can now handle 240 channels, stations in France and Germany will not have that capability until sometime after the first of next year. Italy's station is expected to achieve full capability shortly after that.

● **Jurisdiction disputed**—Meanwhile, the protracted controversy over who should control and operate initial U.S. ground stations continued. Comsat has requested an extension of its deadline for replying to protests by U.S. common carriers. The FCC had ruled that Comsat could construct and operate three new ground stations in the northwest, southwest and northeast corners of the U.S.

Carriers have repeatedly argued that such control would give Comsat an "unwarranted monopoly" of the satellite system that would not be in the public interest.

The FCC has also called for "views and opinions" as to what entities should be authorized to buy satellite service directly from Comsat. Several parties, including American Broadcasting Co., Associated Press and the Washington Post, have requested permission to lease satellite circuits without dealing through the common carriers. Deadline for opinions is Oct. 1.

Apparently still under consideration are tentative plans by American Broadcasting Co. to construct and operate a satellite communications system of its own for news-gathering purposes. United Press International has also expressed an interest in its own system and both organizations have consulted with Hughes Aircraft Co., builder of the *Early Bird.*

Comsat's position is that establishment of a commercial satellite system is a matter entrusted to the corporation under the Communications Satellite Act of 1962. ■

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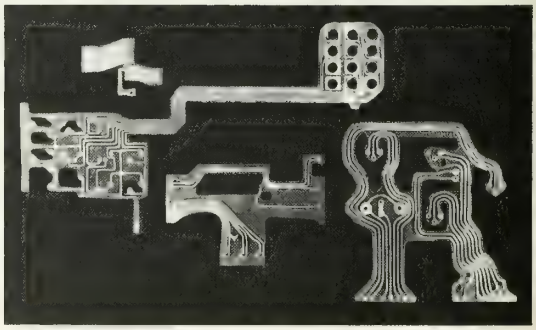
Advantages of TEFLON FEP film: Chemical resistance, liquid oxygen compatibility; also avoids costly and elaborate forming and machining.



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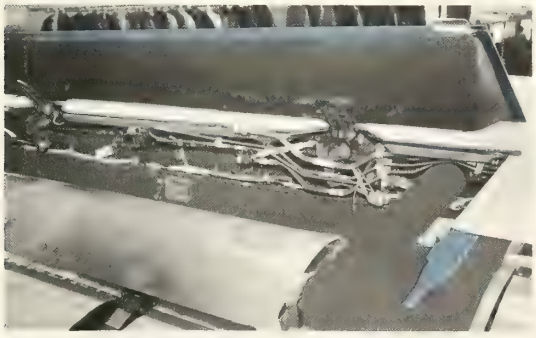
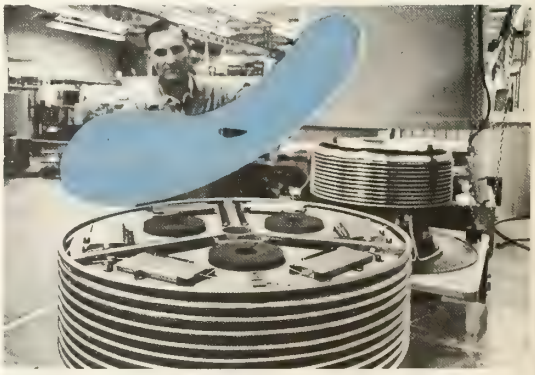
Made by: Garlock, Inc., Cherry Hill, New Jersey.
Construction: Copper laminated between two layers of TEFLON FEP film.
Advantages of TEFLON FEP film: Greater design freedom, reduction of circuit weight and size, superior electrical characteristics and maximum reliability under all environmental conditions.



Dry Surface Lubricant—F-111 Aircraft

Made by: General Dynamics Corporation, Fort Worth, Texas.
Construction: TEFLON FEP film laminated to surfaces in F-111 wing.
Advantages of TEFLON FEP film: Low coefficient of friction, unaffected by fuels and oils, withstands wide temperature ranges and a consistently reliable adherable surface.



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Stress at 5% Elongation (MD)	1900 psi.
Ultimate Elongation (MD)	300%
Tensile Modulus (MD)	70,000 psi.
Impact Strength	2 kg.-cm./mil
Folding Endurance (MIT)	4000 cycles
Tear Strength—propagating (Elmendorf)	125 gms./mil
Tear Strength—initial (Graves)	270 gms./mil
Tear Strength—initial (Graves)	600 lbs./in.
Bursting Strength (Mullen) (1 mil)	11 psi.
Density	2.15
Coefficient of Friction (Kinetic) (Film-to-Film)	.57
Refractive Index (Abbé)	1.341-1.347
Area Factor	12,900 sq. in./lb./mil

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PROPERTY	TYPICAL VALUE
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Weatherability	Inert Outdoors
Permeability	
Gas	cc./(100 sq. in.) (24 hrs.) (atm./mil)
Carbon Dioxide	1,670
Hydrogen	2,200
Nitrogen	320
Oxygen	750
Vapors	gms./(100 sq. in.) (24 hrs./mil)††
Acetic Acid	0.41
Acetone	0.95
Benzene	0.64
Carbon Tetrachloride	0.31
Ethyl Alcohol	0.07
Hexane	0.56
Water	0.40

††Vapor permeabilities are determined at the partial pressure of the vapor at the emperature of the test.

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PROPERTY	TYPICAL VALUE
Melting Point (°F.)	500°-535°F.
(°C.)	260°-280°C.
Service Temperature—continuous	
(°F.)	−425° to +400°F.
(°C.)	−255° to +200°C.
Intermittent	
(°F.)	−425° to +525°F.
(°C.)	−255° to +275°C.
Coefficient of Linear Expansion	4.61×10^{-5} in./in./°F. at −100°F. 5.85×10^{-5} in./in./°F. at +160°F. 9.0×10^{-5} in./in./°F. at +212°F.
Coefficient of Thermal Conductivity	$1.35 \frac{(BTU)(in.)}{(ft.^2)(hr.)(°F.)}$ $4.65 \times 10^{-4} \frac{(cal.)(cm.)}{(cm.^2)(sec.)(°C.)}$
Flammability	Non-flammable
Heat Sealability	Yes
Specific Heat	0.28 BTU/lb./°F.
Shrinkage (1 mil)	MD=0.7% stretch TD=2.2% shrinkage

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PROPERTY	TYPICAL VALUE
Dielectric Strength (1 mil)	6500 volts mil at 25°C., 60 CPS
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Dielectric Constant	2.0 at 25°C., 100 CPS to 100 MC
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Dissipation Factor	.0002-.0007 at 25°C., 100 CPS to 100 MC
Dissipation Factor	.0002 at 1KC, −40° to 225° C.
Dissipation Factor	.0005 at 100 MC, −40° to 240° C.
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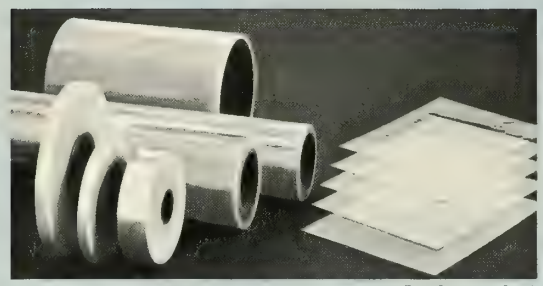

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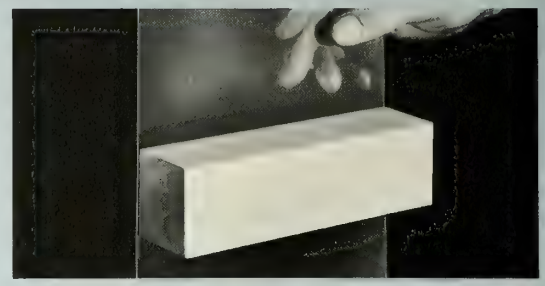

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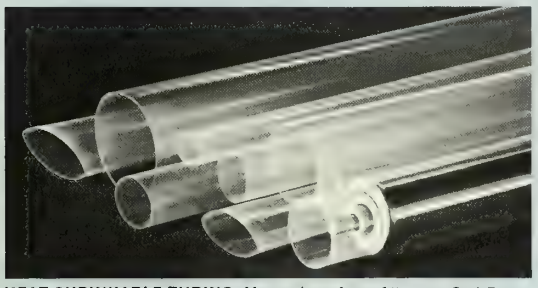

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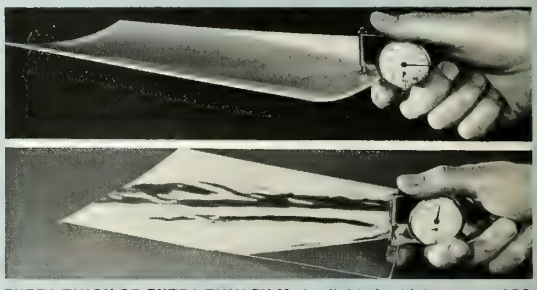

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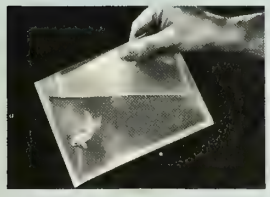

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BETTER THINGS FOR BETTER LIVING
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Radford Is Largest Ordnance Plant

Virginia facility operated by Hercules processes base grains for Minuteman, Polaris upper stages; their production detailed

by John F. Judge

RADFORD, VA.—Propellant ingredients and propulsion systems for all major solid-fueled strategic missiles and the highest-energy solid experimental systems flying today are manufactured at the largest ordnance plant in the U.S. —the Radford Army Ammunition Plant.

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The base grain for the *Athena* rocket, *Medium Anti-tank Weapon* (*MAW*), carpet roll for the Navy and propellant sticks for the *Light Anti-tank Weapon* (*LAW*) are processed by the plant.

Manufacturing capabilities by type include cast rockets, solventless extruded propellant for rockets, rolled sheet propellant, solvent-extruded propellant in single-, double- and triple-base formulations and as composite modified double-base, and igniters.

The plant is now operating at less than full capacity but all equipment and processes are constantly being updated and all processing machinery is maintained on a standby basis.

Commanded by Lt. Col. John W. Sevareid, the Radford Army Ammunition Plant is one of the manufacturing arms of the Ammunition Procurement & Supply Agency, part of the Army Munitions Command, Picatinny Arsenal, Dover, N.J. Processes and ma-

PART OF Radford Army Ammunition Plant. Acid manufacturing complex is at far left. Propellant and powder lines with associated storage and conditioning buildings are at center and across river at top.

chinery to make new propellants developed by Picatinny are devised by Radford production specialists and are worked into routine manufacturing operations by Radford engineers.

● **Impressive safety record**—In spite of the nature of the various products and their ingredients, Radford is consistently at the top of the 50-odd Hercules plants in safety records. As of last May 10, the plant had accumulated some 8,880,000 manhours in 577 days of accident-free operation.

John C. Foster, Hercules plant manager, told MISSILES AND ROCKETS Radford has yet to have a single pound of its product turned back by any user since the plant went into operation in 1941. Both the safety and quality records are points of pride in a facility which routinely manufactures and processes huge quantities of such materials as nitroglycerine and ultra-high-energy propellant ingredients.

There are two major operating departments at the Army Ammunition Plant—one which manufactures acid-nitroglycerine and the other produces nitrocellulose and smokeless powders.

The acid-nitrogclyerine section manufactures both nitric and sulfuric acids and nitroglycerine. Anhydrous ammonia is converted into nitric acid in the facility and the sulfuric acid is used to concentrate the nitric—and this sulfuric is reconcentrated for re-use. The concentrated nitric acid is used in the production of nitroglycerine.

The nitrocellulose department uses these acids and cellulose materials to produce the required nitrocellulose. The smokeless division of the plant combines nitroglycerine and nitrocellulose, along with other ingredients, into designated explosives and propellants.

The manufacturing potential at Radford is enormous. Some 12 million lbs. of nitrocellulose a month can be made. The plant can turn out about 2.5 million lbs. of nitroglycerine in both batch and the Biazzi continuous processes.

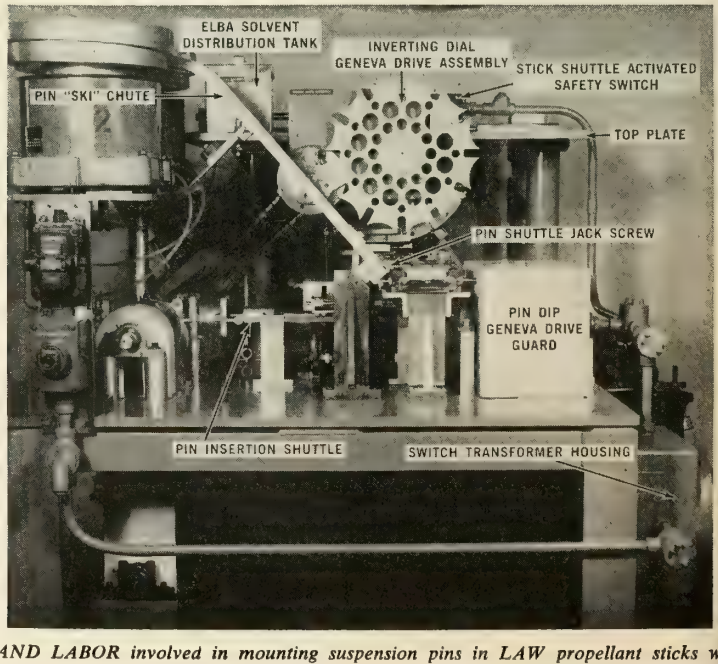
Capacity in large rocket propellant grains is rated at 1 million lbs. per month. Small rocket grains capacity is 850,000 lbs. per month.

In addition, the monthly output ability of the plant is 1 million lbs. in rolled-sheet propellant; 13.8 million lbs. in single-base propellant; 3 million lbs. in double-base propellant; 2 million lbs. in triple-base propellant; 2 million lbs. of single-base, base grain powder; 1 million lbs. double-base, base grain powder, and 300,000 lbs. of composite-modified double base. These capacities are not additive; some lines are multi-purpose.

The production lines at Radford all start in the huge acid manufacturing plant which provides the nitrocellulose and nitroglycerine lines with on-demand concentrated nitric and sulfuric acids.

The capacity of this plant runs to 24 million lbs. of concentrated nitric acid and 4 million lbs. of concentrated sulfuric acid a month. In addition, Radford has a small oleum plant for turning out 107% sulfuric acid.

● **Production sequence**—The acids



HAND LABOR involved in mounting suspension pins in LAW propellant sticks was eliminated through use of this Picatinny-designed processing machine. Unit handles more than 10 times the number of sticks formerly hand-processed in an hour.

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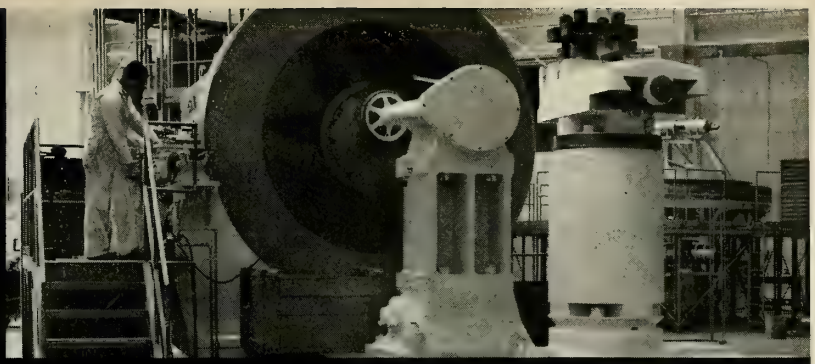

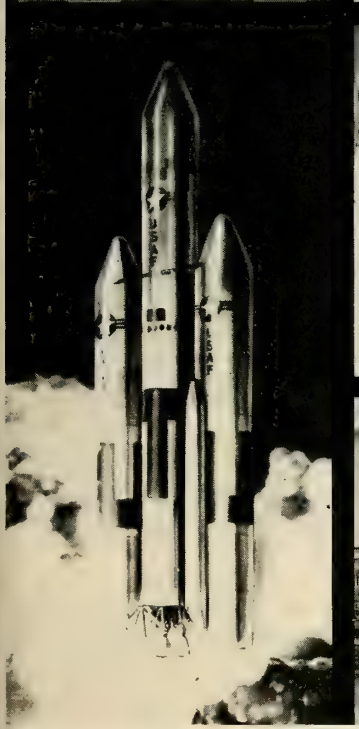

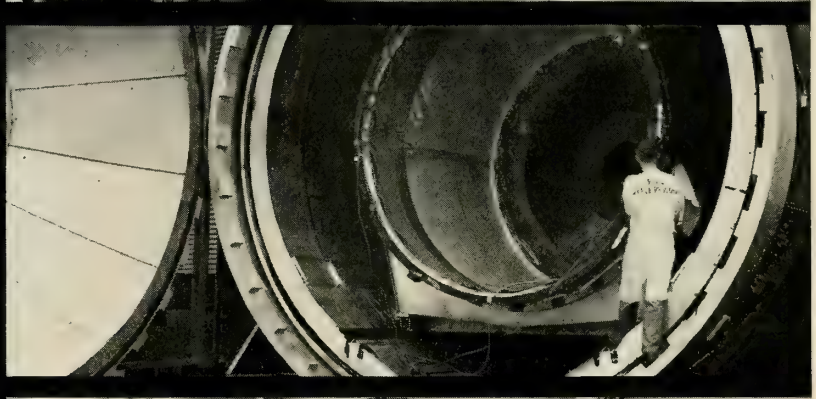

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TITAN III-C BOOSTER INSULATION

Above are fabrication sequences in the insulation of motor cases for the solid rocket strap-ons of the Titan III-C, standard Air Force launch vehicle, recently successfully flight tested at Cape Kennedy. These buna-N rubber insulative components are manufactured by Rohr's Space Products Division to meet United Technology Center's precise requirements. Both precured and cured-in-place techniques are used in insulating the 10-foot diameter center segments and aft closures. These components, varying in thickness from a fraction of an inch to almost a foot, have performed perfectly throughout the motor's extensive development and test program. Reliability is assured by close control of manufacturing processes, including curing under high pressure in Rohr's 15-foot by 35-foot autoclave. Technologies developed at Rohr Space Products Division in the large solid rocket field encompass the full range of insulation materials in use. In addition to providing the insulation, booster intertank structures for the solid boosters on the Titan III-C are also manufactured at Rohr.

For the full story on this and a variety of other nonmetallic fabrication capabilities, please contact: Marketing Manager, Dept. 60, Space Products Division, Rohr Corporation, Riverside, California.

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are routed to the nitrocellulose facility where cotton linters are treated with mixed acids, boiled and then poached to neutralize the acids. The nitrocellulose thus manufactured, containing about 28% moisture, is delivered to the dehydration buildings.

The entire complex is designed to recover and reconcentrate as much of the acids as possible. All through the production lines at Radford the concept of recovery is practiced—little is wasted.

In the *Minuteman* and *Polaris* lines, lots of the nitrocellulose are charged into a hydraulic press in 100-lb. batches, compressed into blocks under 250 psi and dehydrated with ethyl alcohol.

The alcohol is pumped through the block and the block is then subjected to pressures up to 3,500 psi to remove the excess solvent. The resulting block contains about 2.5% moisture and has a total volatile content of 18%.

These blocks are then broken in specially designed equipment and the nitrocellulose is reduced to particles capable of passing a 0.25-in. mesh screen. The block-broken nitrated cotton is weighed into fiber tubs and transported to a pre-mix area where nitroglycerine—desensitized with acetone—is added to the nitrocellulose in a Shrader bowl.

● **Final mix**—The next major step in the operation is the final mix process, which incorporates all ingredients including solvents into a homogenous dough capable of being blocked and extruded.

For those formulations involving HMX, the material is received water wet from the Holston Ordnance Works. Forty pounds of HMX is bagged in cotton and three bags shipped per container.

These bags are removed at Radford, drained and air-dried at 175°F, reducing the moisture content to 3%. The dried HMX is passed through a metal detector—an operation used for most of the ingredient inputs to high-energy propellant base grain processes.

The HMX is weighed and charged to a metal container where the correct amount of acetone is added. The mass stands for about 24 hours to allow the HMX to soak up the acetone.

If the formulation specifies both HMX and ammonium perchlorate, the latter ingredient is spread on top of the HMX in the container. The slurry is then delivered to the mix house.

Ammonium perchlorate preparation at Radford is similar to that used at most propellant plants around the country. The AP is ground to the specified particle sizes, weighed and wicked according to the procedure outlined for the HMX.

(*Continued on page 36*)

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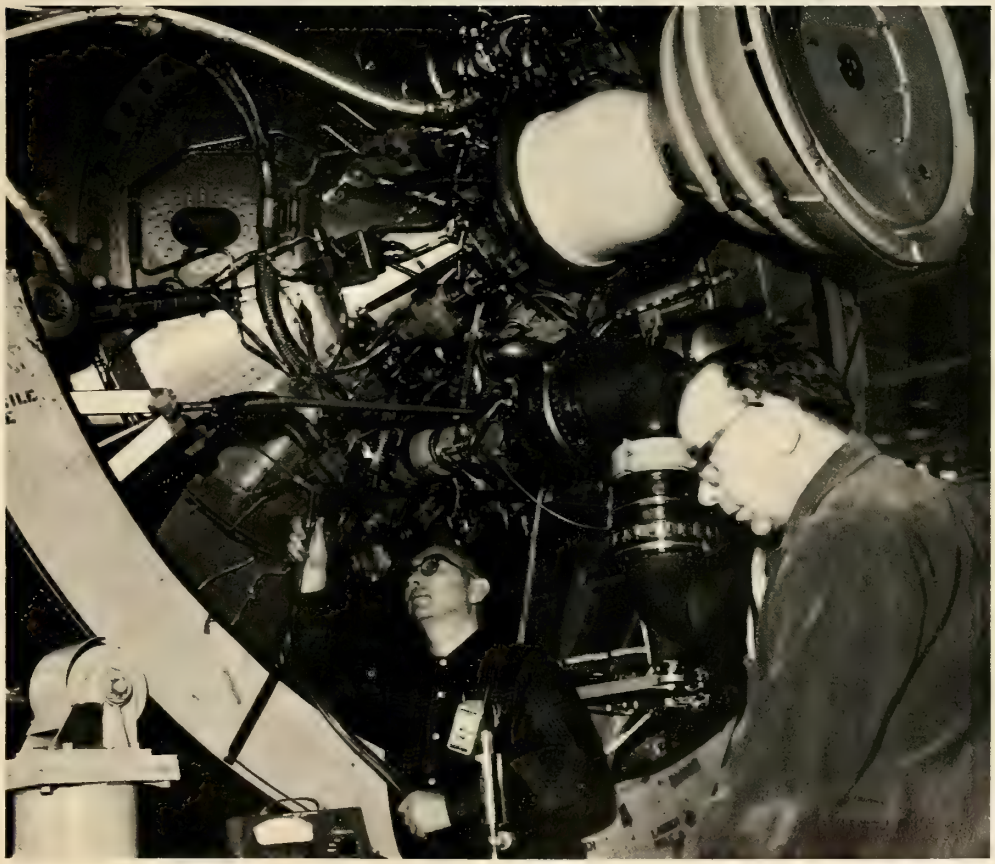

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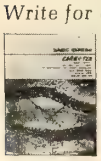

BASE GRAIN for all major weapons systems built by Hercules is cut to correct length in these units at Radford. Propellant strand feed is visible at right.

Other ingredients such as the stabilizer, aluminum powders and resorcinol require no special preparation and are weighed and delivered directly to the final mix can.

At the conclusion of the mixing cycle, the charge, roughly 500 lbs., is loaded into a blocker and again extruded into blocks. These 10-lb. blocks are, in turn, charged to a 4-in. press and extruded through dies to form strands of the specified diameter.

● **Accident precautions**—The blocks are extruded at 800 psi and the strands from the finishing press are extruded at 2,000 psig. Press shots, the burning of the grain while in the pressing position, have been confined to the particular press bay.

The frequency of press shots for all high-energy extrusions at Radford expressed as incidents per 1 million lbs. of powder extruded is 2.88. These incidents, while somewhat more frequent than that for conventional propellants, have generally resulted from the failure of the die bushing due to point loading. This results from metal fatigue caused by the relatively high extrusion pressures.

Die-holder design improvements are expected to eliminate this problem.

The extruded strands are passed through a transfer door and fed to a McKiernan-Terry small-arms cutter, producing granules of the specified length.

These machines are separated by fire screens to prevent propagation. All machines have been upgraded and kept in optimum condition. All units are equipped with magnetic brakes and large stop buttons ready to the operator in the event the strands wrap around the rollers or if there is any indication of fire.

The electrical system is interlocked with the sprinkler system so that all machines on the line stop if the sprinklers are activated.

The cut powder is moved in tubs to a separate building where it is placed in aluminum trays and run through a forced-air dry operation to remove the volatile solvent. This takes some 48 hours.

The dried powder then moves to the finishing building, where it is dumped into a copper buggy. The 900- to 1,000-lb. batches are transported to a remotely operated glazing, blending and screening facility.

Samples of the finished propellant are run through stability, chemical and physical tests as well as procedures for determining screen loading density and gravimetric density.

A second lot sample is sent to the case area, where 40-lb. motors are loaded and statically tested to determine the ballistic characteristics and burning rate of the propellant.

● **On into weapons**—This is the basic production process for the manufacture of base grain powder. These powders are processed into rocket motors for the *Polaris* and *Minuteman* weapons systems.

This base grain powder is shipped to other Hercules plants such as the Bacchus works in Utah or the Allegany Ballistics Laboratory at Cumberland, Md., where it is incorporated into *Minuteman* and *Polaris* motors.

There are casting facilities at Radford for the production of *Honest John, Little John* and the *Nike* motors. The base grain is loaded into molds specially prepared for the particular weapons systems families and cast.

The casting operation involves flooding the grain-loaded molds with casting solvents—a mixture of nitroglycerine and liquid plasticizers—and then curing the mass to a solid monolithic grain. After mold removal, the grains are cut and trimmed and then loaded into the motor cases using a specially designed hydraulic ram setup.

The various cores are remotely pulled from the cured grains before the machining and trimming operations. These latter production steps are also remote operations. ■

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Douglas Tests Helium as Atmosphere

Four subjects spending 18 days in oxygen/helium mixture at various pressures to compare its merits with nitrogen

by Heather M. David

DOUGLAS MISSILES and Space Systems Division began a test last week that will help determine whether helium is a better gas than nitrogen for spacecraft atmospheres. Four men will live in a simulated space cabin for 18 days in an oxygen/helium gas mixture at various pressures.

The pressure will be changed during the test so that its effect upon the environment may be fully understood. The test began with a 5-psi, 70/30 oxygen/helium mixture, a new ratio receiving some consideration from spacecraft designers. (M/R, May 3, p. 15.) Other levels to be tested will be 7-psi, 50/50 oxygen/helium, and 10-psi 35/65 oxygen/helium. In all cases, partial pressure of oxygen is the same as at sea level—3.5 psi.

The 18-day test will combine a number of the various efforts going on at Douglas in support of all the company's space station and extended mission work. Douglas has been study contractor on NASA's *Manned Orbital Research Laboratory* (*MORL*), *Large Orbital Research Laboratory* (*LORL*) and is one of four firms studying the Air Force's *Manned Orbiting Laboratory* (*MOL*).

The space cabin simulator, a company-built device already used for a 30-day oxygen/nitrogen test, is the focal point for development of operational life-support systems. Sixty-day tests are planned in the future, with addition of closed-loop operation and alternate life-support systems. It also contributes to definition of man-machine interface problems, and toward developing better computer programs.

- **Leaning**—Douglas, as several other companies and some Air Force life-support developers, is looking at helium to confirm a number of characteristics that make it appear attractive for space use:

—Apparent absence of decompression sickness problems or bends—Douglas will, for the first time, except in Air Force studies, have its subjects enter an airlock, transferring to a lower pressure. They will then go to simulated pressure suit operation (3.5 psi pure oxygen) to fully check out reports that helium does not form bubbles in the blood, thus making decompression quite safe. The Soviets also are looking at helium because of the problem of transferring easily to extravehicular operation from their sea level, oxygen/nitrogen cabin atmosphere.

—Heat transfer—A more debated point, much of the effort on this test is aimed at getting a definite answer. Some studies have indicated that subjects are more comfortable at higher temperatures than when nitrogen is the diluent. In a two-day pilot run at Douglas at 7 psi, it appeared that subjectively, at least, the men were com-

Mockups of Apollo Modules Face Long Test Series

MOCKUPS of the Lunar Excursion Module and *Apollo* Command Module have been shipped to Wright-Patterson AFB for zero-g testing to verify human factors design.

According to Grumman Aircraft Engineering's Fred Hermann, the LEM mockup will be used in a series of tests that are expected to last at least one year. The mockup, as does that built by North American Aviation for Command Module simulation, has the same geometric interior as the actual LEM. All switches and controls have torque equal to their real counterparts, although they do not activate actual systems. The exteriors are designed with the constraints of the KC-135 in mind.

The tests, which will be performed by a group of five engineers and test subjects from Grumman, will involve pressure-suit simulations of certain aspects of the lunar landing mission. Both pressurized and non-pressurized operations will be conducted.

The first group of tests, involving perhaps 10 flights with from 20 to 30 zero-g parabolas in each flight, will check on mobility aspects. The subjects will enter the LEM, perform visual checks, and actuate circuit breakers.

Ingress and egress studies while the plane is performing $\frac{1}{6}$-g parabolas will then be run, simulating the lunar surface operations. Transfer to and from the Command Module also will be studied.

The group will seek to verify the LEM restraint systems designed by Grumman (M/R, May 17, p. 43), which have been tested in drop tests at the company's Bethpage, N.Y., plant. This consists of a window washer-type belt, Velcro foot pads, and spring-loaded arm rests.

Equipment transfer studies will involve transporting umbilicals, the Portable Life Support System (PLSS), emergency oxygen, cameras, film, tape recorders, scientific equipment, and flight kit from the Command Module to the LEM and installing them in their proper niches. On the return trip, the subjects will carry scientific equipment, camera, PLSS, thermal garment, tape recorders and the flight kit to the Command Module.

In all LEM studies, two subjects will be used at once to simulate the actual mission. Three will operate in the Command Module for those tests. NASA astronauts are expected to come into the program at some later date.

fortable at 82°F. In the 30-day nitrogen/oxygen test, the comfort level was about 77° or 78°. (Both were at fairly low humidity.) Tests at the Garrett Corp. also presented similar indications. However, Air Force doctors at the School of Aerospace Medicine (M/R, May 3, p. 15) think this comfort is merely subjective. A bicycle ergometer and other measuring devices will be used to settle this point.

—No communication problem— Opinions on the effect of helium on communications have been widely revised because of recent testing at the lower pressure spacecraft-type atmosphere. In the early Douglas tests, at 5 psi, it was found that subjects' voices were normal or nearly normal. Although slightly higher in pitch at 7 psi, they were still intelligible.

The "Donald Duck" effect did not occur until pressure neared the one-atmosphere level. Subjects will repeat predetermined phrases and sing songs at various pressure levels, all of which will be taped.

Helium also may have some advantage in efficiency of heat exchanger equipment, the Douglas test indicated. A top NASA official at the Manned Spacecraft Center also has suggested that operation of the gas-sensing system may be facilitated, since helium is relatively further from oxygen on the molecular scale than is nitrogen, making it easier to differentiate.

A slight complication ensues in the use of helium for tests of this type, J. K. Jackson of Douglas's life and environmental systems branch, advance biotechnology department, told MISSILES AND ROCKETS. Jackson said that storage vessels are a little more difficult to design because helium has a much lower boiling point, requiring better insulation for the lower temperatures. This affects some metallurgical materials. Helium also leaks out a little faster than does nitrogen, which might have some bearing in meteoroid puncture.

• **Description of facility**—The Douglas space cabin simulator is a 4,000-cubic-foot chamber of double-wall construction. Inner shell measures 12 feet in diameter by 40 feet long, with an airlock. Pressure in the annulus is kept well below that in the chamber so that any leakage is outward. The facility is designed so that almost any gas pressure combination feasible for space use may be tested.

Atmosphere within the capsule will be maintained by automatic controls developed by Douglas. Oxygen partial pressure is sensed by a polarographic sensor, and total pressure by a strain-gage transducer. Helium is added as needed to make up the pressure. Gas is measured in an unusual pulsed mode.

Gas is supplied to the control at 100 psig from high-pressure storage bottles. Through a pressure regulator, this is reduced to about 30 psig. A control solenoid valve then admits the gas through a fixed orifice with a back-pressure of about 7 psi. Each pulse is approximately 10 seconds, but is regulated for the proper amount.

During the previous 30-day test, 7,454 oxygen pulses occurred, 10.65 per hour. A total of 311 lbs. of oxygen was used, about 1.5 lbs. per day of this for operational procedures such as airlock and pass-through port operation.

Carbon dioxide will be removed by a molecular-sieve regenerable subsystem subcontracted to TRW, Inc. Silica gel is used as a dessicant, and the molecular sieve is thermally de-sorbed under vacuum. Two canisters each of zeolite and silica gel are maintained. According to Douglas engineers, the subsystem is arranged in such a way that it may be removed as a module so that other kinds of CO_2 subsystems may be tested in future operations.

Trace contaminant removal is handled with a catalytic burner subcontracted to Mine Safety Appliances Research. Douglas has had an extensive materials testing program to see that all materials in the cabin are safe and will not produce dangerous or noxious

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outgases. The material samples were placed in liter flasks and evaluated intermittently during a 30-day period before choices were made.

● **Sampling the atmosphere**—Atmosphere within the capsule will be continuously monitored by an infrared analyzer, which gives readings on carbon dioxide, water vapor, carbon monoxide, total hydrocarbons and oxygen. Mine Safety Appliances standard console equipment has the capability of taking samples from 22 locations in the cabin.

Water is removed from the gas stream by an atmospheric condensor with a porous plate water separator. Also subcontracted to TRW, Inc., the unit is designed so that it will operate in weightlessness. Moisture is drawn through the pores of the plate through capillary action.

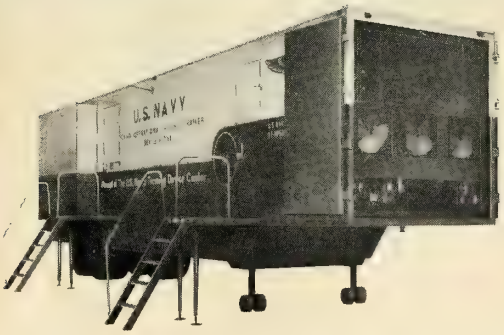
The thermal control system, a development of TRW's Tapco Div., has a cooling capacity in excess of 25,000 Btu per hour. Air flow within the cabin is approximately 1,150 cubic feet/min.

Waste water is collected in tanks and periodically disposed. Bathing will be by sponge bath, although showers were provided in earlier tests. Douglas engineers are looking at water recovery

Apollo Heat Shield Inspected at Avco/RAD

TECHNICIANS at Avco Research and Advanced Development Div., Lowell, Mass., inspect each of the more than 370,000 cells in Apollo Command Module fiberglass honeycomb matrix that will be filled with ablative material. Matrix is bonded by Avco/RAD to brazed steel honeycomb substructure which is shipped from North American Aviation's Space Div. Downey, Calif., prime contractor on the module. Fiberglass honeycomb panel is fitted and bonded to steel structure.

TRAILERS FOR THE SPACE AGE by DORSEY



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techniques for later tests, including electrodialysis, air evaporation, vapor compression, vapor pyrolysis and vacuum distillation.

A space-type commode with a vacuum dehydrator will be used for solid waste management. It also incorporates a zero-g water separator, and filtering system.

Special suits were designed for the previous tests, consisting of two-piece, shirtsleeve garments of light weight. Cowhide moccasins also were worn. Bedding consisted of nylon net beds, cotton and nylon sheets contoured in a sleeping bag and an Acrilan and cotton mattress.

Diet will be monitored carefully to see if the phenomenon which cropped up in an earlier two-day test again occurs. It was noticed that the subjects had an increased caloric intake in that test.

• **Monitoring**—Three TV cameras monitor the interior of the space cabin, and verbal contact is maintained. The men are given an on-board medical supply for small exigencies.

Periodic measurements also are made of electrocardiogram (EKG), blood pressure, respiration rate, temperature, and oxygen consumption. Skin temperature measurements also are being considered.

Subjects in the test will be the same as those previously tested in the 30-day oxygen/nitrogen run. All are students from the University of California at Los Angeles.

Several small breakdowns, such as in the carbon dioxide removal system, brought home to Douglas engineers the value of crew maintenance abilities. Although the CO_2 level mounted during this breakdown, repairs were made before it became dangerous.

Provision of spare parts rather than entirely redundant systems may be preferable, the earlier study indicated. ■

Reprints of NASA Report

Reprints of the entire Special Report on NASA's new Electronics Research Center published in the May 31 issue of MISSILES AND ROCKETS *may be obtained from:*

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Missiles and Rockets
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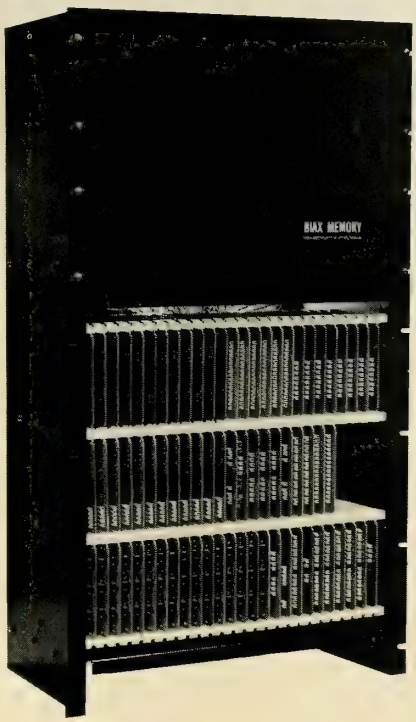

Now you can hike computer and data systems performance with BIAX 2 MC non-destructive readout memories at prices lower than those of coincident-current destructive readout systems for capacities up to 1024 words. For example, the 1024 word x 48 bit BIAX memory shown above can be delivered complete for only $34,050 within thirty days. Other sizes from 128 to 1024 words are also available on short delivery cycle.

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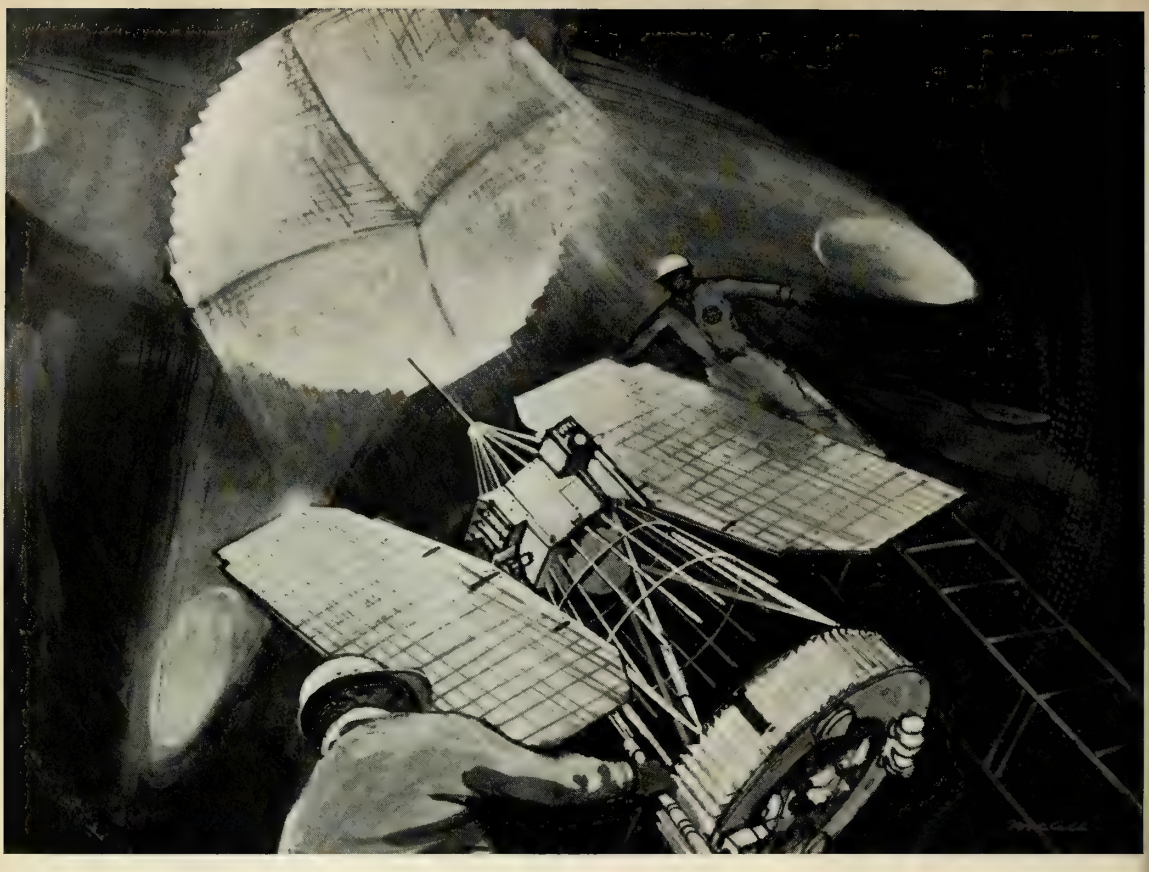

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Interested applicants are invited to inquire further by writing to Mr. J. S. Barson, Dept.394F-4, Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia 1, Pa. An equal opportunity employer.

MISSILE & SPACE DIVISION

GENERAL ELECTRIC

Mergers and Acquisitions

Electro-Optical Systems, Inc., Pasadena, Cailf., has purchased Applied Optics and Mechanics, Inc., of Arcadia, Calif., a privately held manufacturer of aerospace and commercial lens systems. AOM will become a subsidiary of EOS and will continue operation in its present location with its present staff of engineers and technicians. . . . *Control Data Corp., Minneapolis, Minn., has acquired Preston Associates, Inc., Philadelphia, a developer of air- and satellite-borne radar systems. Preston, which has also been active in digital communications systems, will become a part of TRG, Inc., a CDC subsidiary.* . . . Adhesive Engineering Co. of San Carlos, Calif. has announced its May 1 purchase of Lawrence Adhesive & Chemical Co., Lawrence Mass., a manufacturer of epoxy coal tar compounds and other types of structural adhesives and coatings, some of which are used in the aerospace and electronics industries. . . . *Mechanical Technology, Inc., Latham, N.Y., and Miniature Precision Bearings, Inc., Keene, N.H., have laid plans to combine the research and design capabilities of MTI with the marketing and precision manufacturing facilities of MPB for developing and producing standard and special gas bearings.*

New Activities

Radio Corp. of America has established a new Microwave and Power Devices Operations Dept. in Lancanster, Pa. The new department combines the activities of the Microwave Tube Operations and Power Tube Operations departments. . . . *Chemical Micro Milling Co., Philadelphia, has announced the formation of a subsidiary, Chemical Micro Milling of Chicago, located in Elk Grove, Ill., to make photo-etched parts and precision photographic negatives for CMMC customers in the Midwest and on the West Coast. The photo-etched parts produced by the firm are used in mechanical and electronics activities.*

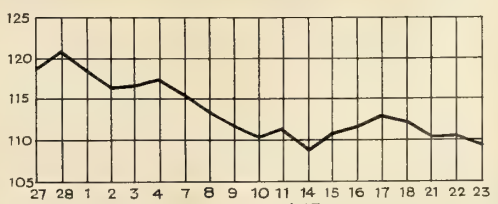
Facility Expansions

Sunbeam Electronics has dedicated a new $3½-million facility in Fort Lauderdale, Fla. The 155,000-sq.-ft. plant will serve as the new headquarters for the firm, based until now in Racine, Wis. . . . *Scientific Data Systems, Santa Monica, Calif., has opened a new center in Rockville, Md., and taken an option to acquire a 21-acre industrial site in El Segundo, Calif. The 14,000-sq.-ft. Maryland facility will combine the Washington, D.C., District Sales Office and Computer Center with a new Eastern Systems Engineering Center. SDS expects the new operation to deliver computer-based systems to customers in the areas by the end of the year. Plans for the California site include a 200,000-sq.-ft. building by mid-1966. SDS manufactures general purpose digital computers for industrial and scientific purposes.* . . . Technical Operations, Inc., of Burlington, Mass., has announced plans to consolidate its San Francisco Bay area activities in a new 40,000-sq.-ft. building in Mountain View, Calif. Included in the move will be Beckman & Whitley, a wholly owned subsidiary in San Carlos; the Western Branch of Tech/Ops Radiation Products Div. in Santa Clara; and Technical Operations Research Western Div. in Sunnyvale. . . . *Hewlett-Packard Co., Palo Alto, Calif., has announced plans to expand its manufacturing plant in Loveland, Colo. Included in the $1.8-million expansion will be a 116,000-sq.-ft. building adjacent to the firms existing 138,500-sq.-ft. facility. The new building, expected to be finished by the summer of 1966, will include a large warehouse, administrative and engineering offices, a cafeteria and special facilities for manufacturing precision electronic components used in Loveland Div. products.* . . . Sperry Rand Corp.'s UNIVAC Div. has announced plans to double the size of its 203,000-sq.-ft. Roseville, Minn., production facilities within the next year. Included in the expansion will be a multi-million-dollar computer center and a 19,000-sq.-ft. ultra-clean, specially lighted area for the manufacture of computer memories, coil-wound products and printed circuit cards. . . . *Crucible Steel Co., Pittsburgh, has announced plans to construct a major addition to its ceramic magnet plant in Elizabethtown, Ky. The expansion will add 15,000 sq. ft. to the 36,000-sq.-ft. present plant.*

International

Honeywell, Inc., has purchased a building in Paris to serve as new headquarters for its French affiliate. The new facility will contain 6,000 sq. ft., more than three times the size of the old headquarters. Honeywell also announced plans to step up marketing efforts in France, Belgium and Switzerland. The firm sells a variety of commercial instruments and controls in Europe, as well as navigation equipment for missiles, spacecraft and aircraft. Honeywell currently employs more than 375 persons in the Paris headquarters, in branch sales and service offices in Lille, Lyon and Marseille, and in a factory in Amiens.

Missile/Space Stock Index



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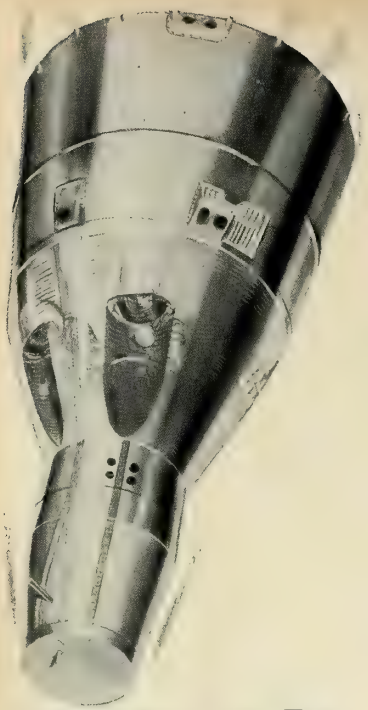

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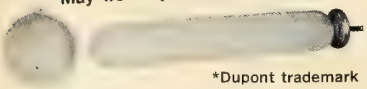

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contracts

AIR FORCE

$8,024,944—**Vitro Corp. of America,** New York City, for maintenance and operation of missile range test areas.

$2,900,000—**I. D. Precision Components Corp.,** Jamaica, N.Y., for manufacture of critical ordnance items.

$2,250,000—**General Electric Co.,** Spacecraft Dept., Valley Forge, Pa., to develop a gravity gradient test satellite.

$2,100,000—**Philco Corp.,** Communications and Electronics Div., Philadelphia, for airborne vocoder equipment.

$1,817,914—**General Electric Co.,** Defense Electronics Div., Syracuse, N.Y., for guidance systems in *Atlas* booster launch vehicles.

$1,700,000—**The Boeing Co.,** Seattle, for missiles and related equipment for the sixth *Minuteman* wing.

$1,626,442—**Radiation, Inc.,** Radiation Service Co., Melbourne, Fla., to continue maintenance of the ballistic missile re-entry data processing system at Holloman AFB, N.M.

$1,600,000—**Philco Corp.,** Western Development Laboratories, Palo Alto, Calif., initial increment on a $1.8 million contract for technical services for satellite control facilities.

$1,175,000—**All American Engineering Co.,** Wilmington, Del., for production of aerial recovery system.

$1,138,800—**The Boeing Co.,** Seattle, for testing the *Minuteman* system in Ogden, Utah.

$1,000,000—**Ets Hokin Corp.,** Censco Div., San Francisco, for container sets for the *Sparrow III* missile.

$219,000—**General Telephone and Electronics Corp.,** Sylvania Electric Products Inc., New York City, to install special-purpose electronic receiving equipment overseas.

$74,792—**Hughes Aircraft Co.,** Aerospace Group, Culver City, Calif., for a feasibility study of laser ranging systems.

$44,354—**United Aircraft Corp.,** United Technology Center, Sunnyvale, Calif., for study of ignition and combustion mechanisms of solid propellants systems.

$28,391—**Martin Marietta Corp.,** Orlando, Fla., for combustion of high-energy pyrophoric fuels.

Federal Scientific Corp., New York City, for an experimental model of a multiple-pulse coherent memory filter (amount not disclosed).

ARMY

$4,500,000—**Texas Instruments, Inc.,** Dallas, for classified electronic equipment.

$1,713,880—**Allied-Webb,** South Gate, Calif., for alterations and additions to pad 2, pad 3, *Titan III-X,* Vandenberg AFB, Calif.

$600,000—**Thiokol Chemical Corp.,** Ogden, Utah, for rocket launcher.

$552,270—**Operations Research Inc.,** Silver Spring, Md., to conduct weapons systems analysis of military service requirements for testing chemical and biological weapon system.

$474,939—**General Dynamics Corp.,** Pomona, Calif., for industrial product and production engineering services on *Redeye* guided missile.

$203,000—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., for nine-month research study of microdecoy feasibility demonstration of penetration aids.

$150,000—**Rohm and Haas Co.,** Redstone Arsenal Research Div., Redstone Arsenal, Ala., contract modification for devising improved processing techniques for high-energy propellant ingredients or raw materials for rocket motors.

$116,429—**General Dynamics Corp.,** Pomona, Calif., for industrial product and production engineering services on *Redeye* guided missile.

$98,455—**Collins Radio Co.,** Dallas Div., Dallas, for radar study and improvement program for Project Dazzle.

$94,963—**Thiokol Chemical Corp.,** Huntsville Div., Redstone Arsenal, Ala., for synthesis and evaluation of high-energy polymers.

$73,074—**Hughes Aircraft Co.,** Aeronautical Systems Div., Culver City, Calif., for three-month study of laser air defense system.

$40,000—**Northrop Corp.,** Newbury Park, Calif., for research on nuclear effects on instrumentation.

$34,700—**Spaco, Inc.,** Huntsville, Ala., for rocket motor cases and related components for Micaw program.

$30,500—**Zero Manufacturing Co.,** Silver Spring, Md., for extended range *Shillelagh* missile containers.

NAVY

$11,600,000—**General Telephone and Electronics** Corp., Sylvania Electronic Systems Div., Needham, Mass., for 59 shipborne computers.

$6,348,644—**Westinghouse Electric Corp.,** Pittsburgh, for reactor plant components in nuclear-powered ships.

$2,586,462—**The Bendix Corp.,** Oxnard, Calif., for instrumentation systems and associated range facilities.

$1,796,000—**Control Data Corp.,** Minneapolis, for MK 148 target card computers.

$1,000,000—**Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for an examination of possible wider application of the F-111B missile system.

$717,884—**Sperry Rand Corp.,** Sperry Gyroscope Co., Great Neck, N.Y., program definition phase contract to recommend methods for doubling performance of *Polaris* submarine navigation in connection with *Poseidon* program.

$533,231—**Philco Corp.,** Western Development Laboratories, Palo Alto, Calif., for design, fabrication and installation of an operational satellite control system and documentation.

$331,000—**Raytheon Co.,** Lexington, Mass., study contract on the guidance electronics package for the *Poseidon* missile program.

$148,485—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., increase in contract for AN/ARC-38A program.

$99,475—**Hewlett Packard Co.,** Dymec Div., Palo Alto, Calif., for *Shrike* guidance test stations.

$49,808—**University of Washington,** Applied Physics Laboratory, Seattle, for facilities and services for support of Project X—research and development of underwater ordnance.

$29,270—**United Aircraft Corp.,** Norden Div., Norwalk, Conn., for telemetry systems.

$25,341—**Westinghouse Electric Corp.,** Aerospace Div., Baltimore, for services to investigate atmospheric and target parameters.

NASA

$11,163,051—**General Tire and Rubber Co.,** Aerojet-General Corp., El Monte, Calif., to design and make three exhaust nozzles to be used in testing the Phoebus nuclear rocket reactor.

$3,740,000—**Radio Corp. of America,** Astro-Electronics Div., Princeton, N.J., for *Tiros* Series III project.

$661,500—**Hughes Aircraft Co.,** Los Angeles, for *Applications Technology Satellite* VHF transponder experiment.

$556,362—**Wyle Maddox,** Chincoteague, Va., for construction of Weather Bureau satellite station at Wallops Island.

$501,844—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for modification, fabrication, extended testing and evaluation of electron bombardment cesium ion engine systems.

$480,980—**United Aircraft Corp.,** United Technology Center, Sunnyvale, Calif., for continuation of research on the technological development of throttling a hybrid propulsion system.

$315,000—**United Nuclear Corp.,** White Plains, N.Y., for a gamma probe device to be used to determine radiation protection astronauts will receive from *Apollo* vehicle structure against solar radiation fields that may be met during lunar voyage.

$247,000—**Booz, Allen Applied Research Inc.,** Washington, D.C., for a manned spacecraft parametric cost analysis program.

$238,568—**Technical Appliance Corp.,** Sherburne, N.Y., for six SATAN receiver antenna arrays.

$227,000—**TRW/Space Technology Laboratories,** Redondo Beach, Calif., for study to determine thermo-physical properties of ablative materials.

$166,000—**Computer Control Co., Inc.,** Western Div., Los Angeles, for magnetic tape unit.

$165,000—**TRW/Space Technology Laboratories,** Redondo Beach, Calif., for development of computer programs for analytical predictions of delivering specific impulse.

$157,000—**Bell Aerospace Corp.,** Aerosystems Co., Buffalo, N.Y., for propellant tank assemblies.

$149,223—**Allis Chalmers,** Research Div., Milwaukee, to extend and expand research and development effort on fuel cells.

$125,000—**General Dynamics Corp.,** Convair Div., San Diego, Calif., for design criteria for control of space vehicle during launch phase of flight.

$94,470—**System Sciences Corp.,** Falls Church, Va., for analysis of communications and navigation satellite system concepts.

$82,488—**Northrop Corp., Space Laboratories,** Hawthorne, Calif., for determination of *Apollo* emergency impact limits.

$47,496—**Litton Systems, Inc.,** Applied Science Div., St. Paul, Minn., for research associated with investigation of sputtering effects on the surface of the Moon.

$33,700—**North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., for experimental evaluation of the *Pegasus* satellite meteoroid detection system.

INDUSTRY

$675,000—**Edgerton, Germeshausen and Grier, Inc.,** Boston, from **The Boeing Co.,** Michoud Operations, New Orleans, La., to develop flash illuminating systems for the *Saturn V* launch vehicle.

$220,000—**International Telephone and Telegraph Corp.,** Cannon Electric Div., Los Angeles, from **The Boeing Co.,** Launch Systems Branch, New Orleans, for KPTM and CWLD connectors for ground support equipment on the *Saturn* project.

Textron, Inc., Bell Aerosystems Co., Buffalo, N.Y., from **United Aircraft Corp.,** Hamilton Standard Div., Windsor Locks, Conn., to provide the positive expulsion water tanks for the environmental control system of Project *Apollo's* Lunar Excursion Module (amount not disclosed).

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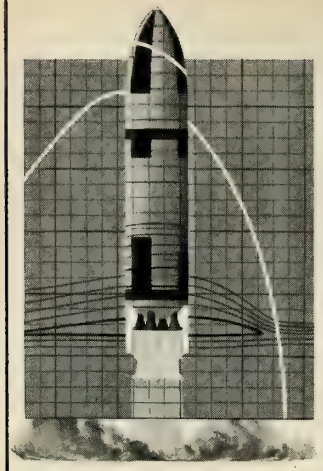

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STRUCTURAL DYNAMICS—Basic loads, environments, structural criteria, aero-elasticity, shock, vibration, acoustics, and structural feedback functions for analysis of controls stability.

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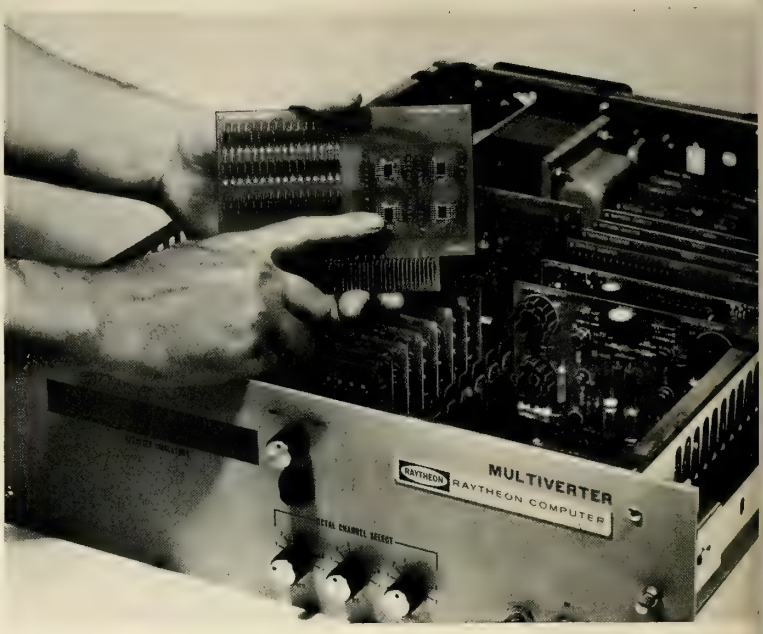

New Product of the Week: Multiverter Data System

A data system that combines an integrated circuit multiplexer, an advanced sample and hold amplifier and an analog-to-digital converter in a single chassis is being marketed by Raytheon Co.

The Multiverter ® system has typical application as an oceanographic data acquisition system, a digital computer-controlled data system or a hybrid computing system. The unit replaces three or more chassis normally required for the "analog front end" in data acquisition and processing systems.

The system provides 12-bit data throughput at 50 kc or 15-bit throughput at 30 kc. System accuracy is 0.02%; data sampling aperture time is less than 100 nanoseconds. Input data voltage is ±10 to ±128v; input impedence is 1,000 megohms.

The system can be operated in sequential or random address modes. Manual and calibrate mode control switches are available for calibration and dynamic tests.

Circle No. 151 on Subscriber Service Card

Laser Interferometer

An automatic laser interferometer with a computer-corrected dynamic digital readout has been developed by OPTOmechanisms, Inc.

The Model 437/510 measures linear displacement by electronic counting of laser intereference fringes generated as a result of the motion of the cube corner reflector in relation to the sensor. The unit consists of a sensor, a reflector and an electronic console with digital readout. The sensor contains the interferometer optics, the laser light source, interference fringe sensors and electronic preamplifiers.

The device's integral system continuously calibrates measurements for variations in atmospheric temperature and pressure, in addition to the temperature of the part being measured.

Circle No. 152 on Subscriber Service Card

Cube Thermistor

A miniature cube thermistor, offering thermally bonded ribbon leads as a standard feature, has been developed by General Electric Co.

The unit measures 0.032 in. square and 0.012 in. thick and is available in GE standard grades 1 through 4. Resistance values are from 100,000 to 20 ohms and resistance ratios from 48.78 to 12.95. Thermal time response is 2.5 seconds with a dissipation constant of 0.7 milliwatt per degree C.

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At the
AIAA Show, July 26-29
IN SAN FRANCISCO
missile/space daily will provide complete coverage:

news

Ten editors, under the direction of Bill Coughlin, VP and Editorial Director of AMERICAN AVIATION PUBLICATIONS, and Bill Hall, Editor of MISSILE/SPACE DAILY will be at the Show reporting all important developments.

advertising

During the four days of the show, MISSILE/SPACE DAILY will provide exhibitors and non-exhibitors an outstanding opportunity to sell their products and capabilities with low-cost advertising.

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MISSILE/SPACE DAILY

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MISSILES AND ROCKETS

PUBLISHING DATE: JULY 19, 1965

ADVERTISING CLOSES: JULY 6, 1965

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names in the news

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William R. Hutchins: Appointed vice president-advanced development of National Company, Inc. He was formerly director of Eastern Technical Operations of the Aerospace Corp.

Paul J. Meeks: Elected a vice president of Space-General Corp. He is responsible for production management of the second-stage of the liquid injection thrust vector control system for the *Minuteman*.

Henry Muller: Installed June 15 as president of The American Society of Mechanical Engineers. He is vice president of engineering, Canadian Westinghouse Co., Ltd., Hamilton, Ontario, Canada. He is the first president to reside and work outside the United States.

Eugene E. Surdyk (USA-Ret.): Joined Ling-Temco-Vought, Inc., as Washington public relations representative. He was formerly assistant chief of information for the Army.

Charles F. Pitts: Appointed executive vice president and general manager of the Lear Siegler, Inc., Astronics Div. Also appointed was **Walter J. Kruel** as executive vice president and general manager of the LSI Electronic Instrumentation Div.

William O. Miller: Appointed public relations director of Lockheed Shipbuilding and Construction Co.

Charles R. Newman: Promoted to senior vice president of Quantic Industries, Inc. He is co-founder of the company. Jack Kimble, president of Magnetic Technology, Inc., a wholly-owned subsidiary, has been elected a vice president.

W. Lewis Hyde: Named director of the Institute of Optics at the University of Rochester. He is associate dean of the College of Engineering and Applied Science and professor of optics.

Donald F. Fagan: Appointed manager of advanced programs at Fairchild Hiller's Electronic Systems Div. He was formerly with Huyck Systems Co.

Dr. Roger Langmaid: Joined Reeves Soundcraft as manager of research. He will direct the firm's developmental programs with regard to sound recording, video, computer and instrumentation tapes and tape products.

Wallace A. Lien: Named vice president of Endevco Corp. He was formerly general manager of Digitran Co., a division of the corporation.

Bruno M. Pompei: Promoted to director of international operations for LFE Electronics, a division of Laboratory for Electronics, Inc.

William M. Lower: Appointed vice president and general manager of Ferranti Electronics, a division of Ferranti-Packard Electric, Ltd.

Stewart F. Sando: Named *Gemini* program manager for the Florida aeronautical division of Honeywell, Inc. He was formerly technical director of the program.

George K. Sneden, Jr.: Named manager of cryogenic systems in the newly reorganized Hofman-Paul Cryogenic Div. of the Air Reduction Co. Also named was **John Holm** as director of marketing for Hofman Laboratories.

Philip T. Tobin: Named assistant treasurer of Sperry Rand Corp.'s Univac Div. He was formerly with Vickers Inc.

Sven H. Dodington: Elected chairman of the board of directors of the National Aerospace Electronics Conference. He is vice president of research and development for International Telephone and Telegraph Corp.'s Federal Laboratories.

Dr. Wernher von Braun: Named recipient of the 1965 AIAA Louis W. Hill Space Transportation Award for "significant contribution indicative of American enterprise and ingenuity in the art and science of space flight."

Robert H. Sorenson: Named to head the newly-formed Electro-Optical Group at Perkin-Elmer Corp. A vice president, he will also retain his responsibility as general manager of the Electro-Optical Div., a part of the new group. **Henry F. Brockschmidt,** a vice president and previously in charge of corporate business development, has been named general manager of the Astro-Optical Div. of the group.

Walter W. Wilson: Joined Rocket Research Corp. as an engineering specialist. He was formerly with Lockheed Missiles and Space Co.

when and where

JUNE

Annual Meeting of the National Society of Professional Engineers, Western Skies Motor Hotel, Albuquerque, N.M., June 30-July 3.

JULY

Meeting of the Advisory Group for Aeronautical Research and Development, NATO, Paris, July 2-3.

Symposium on Meteorological Data Processing, sponsored by the International Union of Geodesy and Geophysics, World Meteorological Organization, Brussels, July 2-5.

International Union of Pure and Applied Chemistry Conference, Paris, July 2-9.

International Astrophysical Symposium, sponsored by the Astrophysical Institute of the University of Liège, Liège, Belgium, July 5-7.

Gordon Research Conferences, (Polymers), New London, N.H., July 5-9.

Pricing and Negotiating Prime and Sub-Contracts in the Defense and Aerospace Industries, sponsored by Contract Management Institute, Shoreham Hotel, Washington, D.C., July 6-10.

Eighth Annual Institute in Technical and Industrial Communications, sponsored by Colorado State University, Coloradio State University, Fort Collins, July 6-10.

The Impact of Educational Technology, sponsored by American Management Assn., The Americana Hotel, New York City, July 12-16.

Gordon Research Conferences (Chemistry and Metallurgy of Semiconductors), Andover, N.H., July 12-16.

Annual IEEE Conference on Nuclear and Space Radiation Effects, sponsored by the Institute of Electrical and Electronics Engineers, University of Michigan, Ann Arbor, July 12-16.

Advanced Science Seminar in Experimental Techniques in High-Speed Aerodynamics and Gasdynamics, sponsored by the National Science Foundation, Ohio State University, Columbus, July 12-23.

Aerospace Vehicle Flight Control Conference, sponsored by the Society of Automotive Engineers and NASA, International Hotel, Los Angeles, July 13-15.

European Space Symposium, sponsored by Eurospace (in conjunction with the International Exhibition of Transport), Munich, July 19-22.

Second Annual Meeting and Technical Display of the American Institute of Aeronautics and Astronautics, Civic Center, San Francisco, July 26-29.

Aerospace Reliability and Maintainability Conference, sponsored by the American Society of Mechanical Engineers, American Institute of Aeronautics and Astronautics and the Society of Automotive Engineers, Statler Hilton Hotel, Los Angeles, July 28-30.

AUGUST

Eighth Annual Space Technology Institute, sponsored by Air Force Systems Command, NASA, and University of Connecticut, University of Connecticut, Storrs, Aug. 1-13.

Tenth Technical Symposium, sponsored by Society of Photo-optical Instrumentation Engineers and Air Force Systems Command, Jack Tar Hotel, San Francisco, Aug. 16-20.

1965 National Meeting of the American Astronautical Society, Sheraton-Palace, San Francisco, Aug. 18-20.

International Lunar Geological Field Conference, sponsored by University of Oregon and New York Academy of Sciences, Bend, Ore., Aug. 22-28.

Conference on the Exploration of Mars and Venus, sponsored by Virginia Polytechnic Institute, NASA, and Air Force Cambridge Research Laboratory, Blacksburg, Va., Aug. 23-27.

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How Not to Sell Abroad

Bretigny, France

ANY U.S. MARKETING executive interested in learning how NOT to sell abroad need only visit the French national space center near this small village southeast of Paris.

The space program is under the direction of the Centre National D'Etudes Spatiales (CNES)—the French counterpart of the National Aeronautics and Space Administration. By U.S. or Soviet standards, the French effort is a very modest one. In addition to its international space commitments, the De Gaulle government is putting some $42 million this year into a space program of its own.

Despite the limited nature of the program, the government is showing a strong awareness of the importance of advanced technology to the nation. The program is an across-the-board effort designed to develop competence in all those areas of technology important to future success in space. More comprehensive than that of any other country in Europe, the program nevertheless is still in its infancy. The French space center, while well along in construction, still is far from complete. The first all-French satellite *(D-1)* is to be launched by the *Diamant* rocket next year.

In seeking to develop a competence in space technology, CNES turned toward the U.S. for help, both to NASA and to private industry. The relationship with NASA, which is to launch the CNES *FR-1* satellite aboard a *Scout,* is characterized by CNES officials as outstandingly successful.

"We are extremely happy with the help and assistance we have received from NASA," says Jean-Pierre Causse, director of the satellite division of CNES.

The relationship with U.S. industrial firms, however, has left much to be desired. Obviously, the market for U.S. equipment in the French space program is not a large one, nor will it ever be. It could, however, be considered substantial, with initial purchases running into millions of dollars.

The hope at CNES was to buy well-qualified equipment in certain areas while undertaking to develop its own competence in others.

"We were not understood," says the CNES official. "We were trying to buy peace of mind—to get rid of problems by buying American. Problems we can solve here."

The awakening was a rude one. The French discovered that the glittering advertising claims for much of the equipment far exceeded performance. They expected superior quality and superior reliability. What they got was something different.

Telemetry equipment arrived that was improperly wired. Unable to repair it, CNES shipped it back to the U.S. and entered into protracted long-distance negotiation to bring it up to standard.

Three recorders were purchased from three separate U.S. firms, each of them a contender for an order of 25 of these at some $40,000 each. None of the three met specifications. Only after considerable argument were they overhauled.

This was not true of all U.S. equipment purchased. But it was true of enough so that officials at CNES were pretty thoroughly disillusioned. What market there might have been in the French space program for U.S. firms has been substantially reduced as a result of this performance.

Already handicapped by distance and complex commercial involvements such as the necessity to deal through import-export houses rather than directly with the factory, the U.S. marketing effort in France, or elsewhere in Europe, simply cannot withstand failure to deliver the performance promised.

Admittedly, some of the difficulties arose because CNES officials lacked the sophistication in space technology to know just exactly what to specify. Naively, they put themselves in the hands of U.S. salesmen who not only sold them the equipment, but wrote the specifications. Later, it developed in some instances that the specifications themselves were not high enough.

"We could have given you better equipment," the French were told, "but you didn't specify it." When CNES officials pointed out that the firm involved had itself drawn up the specifications, they got little satisfaction.

In another case, an American firm insisted that components purchased by the French be supplied by its European licensee, which still was in a training program. The components supplied were unsatisfactory and eventually replaced by U.S.-made goods.

CNES officials feel that many U.S. suppliers did not put the same effort into quality control on equipment bound for France that went into the same equipment going to the U.S. space program.

"The attitude was, it's good enough for the French; they won't know the difference," Jean-Pierre Causse says. "If NASA had gotten that equipment, there would have been hell raised."

THE AMERICAN FIRMS involved are not all small ones. Some are among the giants of the missile/space industry. The black eye given to their marketing effort in Europe will not be overcome for some time, certainly not in France.

Those firms that did deliver on their promises, however, will find themselves in an enhanced position as the French space program expands.

A number of U.S. firms have found other routes to participation in the French program. One reached an agreement with a French company, trained the French technicians in its capability and now receives a royalty on sale of the product to CNES. This has an added advantage in the eyes of the French space agency, for it transfers know-how in space technology into the French economy. Other U.S. firms work through technical agreements with French firms or through joint companies.

Whatever the route, the U.S. marketing effort in France today is more difficult because a few companies have left a sour taste as their main contribution to the French space program. A visit to CNES is indeed educational—but a little hard on the American pride.

William J. Coughlin

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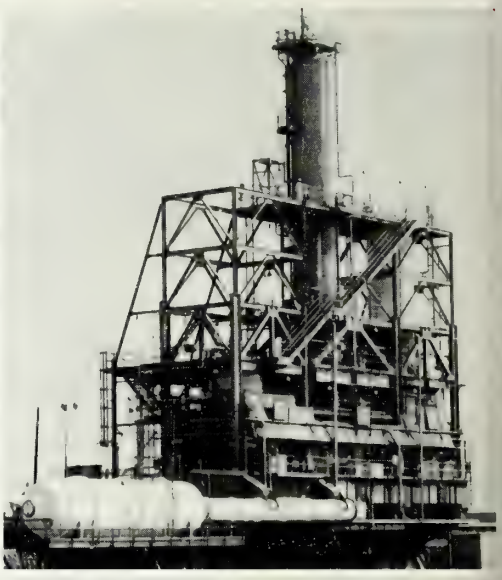

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missiles and rockets

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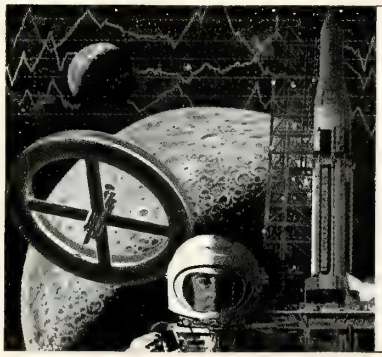

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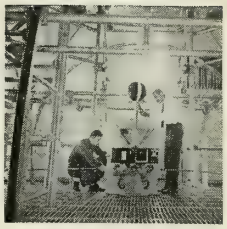

THE COVER

What is described as the free world's most advanced magnetic facility for testing spacecraft went operational recently at NASA's Goddard Space Flight Center. Shown here being checked out is a model of the Interplanetary Monitoring Platform minus solar paddles.

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letters

Uncommon Language

To the Editor:

Well, the "M" million, "m" thousand controversy is taking off like the *Titan III-C*. As an Engineering Writer I'd like to add my small voice to the din.

Mr. Bryant A. Langmuir (in Letters, M/R, June 21) questions M for million as "Whose long-standing practice?" He goes on to say that M is "the generally accepted abbreviation for *thousand*." The argument boils down to a matter of where one is standing at the moment.

In a print shop or paper manufacturing house, "Ship 3M" will mean "ship three thousand," but to be comprehensible to an engineer, a three-thousand-ohm resistor would have to be referred to as "a 3k resistor"—the k coming from "kilo," the "standard" prefix for *thousand* in the metric system.

To carry the foolishness further, the engineer will usually look upon an "m" from a seat a thousand miles away from the printer, since to the engineer or scientist the abbreviations msec (millisecond), mm (millimeter), mw (milliwatt), etc. mean a *thousandth* of a second, meter, watt, etc.

Of course, the local water supply authority will refer to water hardness in terms of "ppm"—parts per *million*—and the power and light company will talk about "MW"—megawatt (one million watts)—while, personally, I take the coward's way out: avoid abbreviations.

Morton A. Berger
Engineering Writer
General Electric Company
Syracuse, N.Y.

To the Editor:

I dislike appearing to be a nit picker, but with confusion about abbreviations already rampant, I dislike even more seeing the confusion compounded by your note to Mr. Langmuir.

The answer to Mr. Langmuir's question "Whose long-standing practice?" is scientists and engineers everywhere and a large part of the rest of the world's population, including, no doubt, Mr. Langmuir himself for some purposes.

The capital letter M is indeed used for million, or "mega-." This is not a newly established convention. How long have you been hearing of megacycles? Or even megabucks? The lower-case m is not used for thousands as you state, but for *thousandths* (milli-). Neither is this new. Ever hear of millimeter (mm), milliliter (ml), or millisecond (msec)? The symbol used by scientists for thousands is k, for "kilo-": kilocycle, kiloton, kilometer, kilogram, kilowatt.

I shall be very much surprised if even Mr. Langmuir does not pay for his household electricity by the kilowatt-hour and tune his raido to frequencies measured in kilocycles per second and megacycles per second. He may soon have to change those kilocycles and megacycles to kilohertz (kHz) and megahertz (MHz), but to discuss that would take me too far afield.

I refer both you and Mr. Langmuir to the *National Bureau of Standards Technical News Bulletin*, April, 1964, page 61, and *Physics Today*, June, 1962. page 19.

John M. Taylor, Jr.
Physicist
U.S. Navy Underwater Sound Reference Laboratory
Orlando, Fla.

(*We really meant to say thousandths.—Ed.*)

AF Materials Coverage

To the Editor:

I have just read your excellent and timely report on our 1965 Air Force Materials Symposium ("Corrosion Hampers AF Development," M/R, June 14, p. 26). John F. Judge's professional competence in this field is obvious and most commendable.

My sincerest appreciation and thanks for an extremely fine coverage.

Lee R. Standifer
Colonel, USAF
Director
Air Force Materials Laboratory
Wright-Patterson AFB, Ohio

Hands Across Space

To the Editor:

It was gratifying to see the photo of Astronauts McDivitt and White and Cosmonaut Gagarin shaking hands with such obvious enjoyment at the Paris Air Show (M/R, June 28, p. 16).

One gathers that they are all much happier being engaged in a healthy space race than they were when employed in flying military aircraft.

John McDonald
Minneapolis

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The Countdown

WASHINGTON

MOL Briefing in Final Phases

Although DOD would neither confirm nor deny it, signs were plentiful last week that the *Manned Orbiting Laboratory* (*MOL*) briefing process has finally reached the top at the Pentagon. Oral presentations by industry competitors, presented several weeks earlier to DDR&E boss Dr. Harold Brown, were prepared, complete with textual backup, for briefing Defense Secretary McNamara. A meeting of the National Aeronautics and Space Council on *MOL*, scheduled by Vice President Humphrey for July 1, was moved back to July 9. But indications were a Pentagon *MOL* briefing of Humphrey was substituted on the earlier date. The NASC session is intended to include briefings by both McNamara and NASA Administrator Webb on separate studies of the *Gemini*/canister and *Apollo* approaches to *MOL*.

Supplemental $1 Billion for Defense?

Increasing pressure is being put on the Administration to ask for a supplemental Fiscal Year 1966 Dept. of Defense appropriation of $1 billion or more. Drain of the Vietnamese and Dominican efforts on a budget prepared 18 months before those crises existed is causing a great deal of concern among top Congressional leaders. In addition to a large faction in the House, Senators John Stennis (D-Miss.) and Leverett Saltonstall (R-Mass.) have been most outspoken in their worry. Both are top-ranking members of the Armed Services and Appropriations committees—hence among the very few who are privy to all the nation's military secrets.

NASA Sticking to Surveyor Booster Plans

Space agency officials say the success of the *Titan III-C* launch in no way alters their plans to use *Atlas/Centaur* and *Saturn IB/Centaur* for the *Surveyor* and *Voyager* programs—missions which some Congressmen and Air Force officers believe *Titan* could perform successfully. NASA declares that in all of its studies of the comparative merits of the launch vehicles it always assumed that *Titan III-C* would be successful. But it says that switching to a new vehicle for *Surveyor* would cost time and money.

Borman and Lovell Slated for Gemini 7

Astronauts Frank Borman and James A. Lovell will be the primary crew for the *GT-7* mission now scheduled for early next year. Backup crew will be composed of Edward H. White and Michael Collins. James McDivitt was originally expected to be backup command pilot, but it has been decided that he will serve as capsule communicator at the Mission Control Center.

Scientist/Astronauts To Pick Experiments

The six new scientist/astronauts are expected to specialize in selecting and developing *Gemini* and *Apollo* experiments. Manned Spacecraft Center Robert Gilruth says one of the activities of the group over the next few years will be seeing that "we carry the right kind of experiments to the Moon and that the crews are properly trained."

NASA Moves Toward AES Team Choice

NASA's Manned Space Flight officials—after preliminary study—have tentatively decided there will be various advantages in having two different field centers share direction of *Apollo Extension Systems* development. As a result, top management has been told to make a detailed study of using two centers and probably two payload integration contractors. A final decision is expected in two to three months. Meanwhile, the Manned Spacecraft Center in the next few weeks will issue RFP's for the first-phase study of the payload integration contract for all *AES* missions in its first three-year flight schedule.

Space Agency To Train Airmen in Control

NASA and DOD will announce shortly an agreement under which the civilian agency will train about 125 Air Force personnel in mission control and tracking station duties. The men will help NASA control and track its long-duration *Gemini* missions, and also eventually serve as mission control crew for AF *MOL* flights. There's no decision yet as to whether the Air Force will use Manned Spacecraft Center's Mission Control Center for *MOL* flights or develop its own facilities.

INDUSTRY

Cape Contractors Busily Recruiting

NASA support contractors at Cape Kennedy expect to hire more than one thousand new personnel by the end of this calendar year. This will raise contractor employment from 3,093 to 4,240. Major firms who will hire are Trans World Airlines, RCA, Ling-Temco-Vought, Bendix, Dow Chemical, Federal Electric Corp. and Bechtel. TWA, which holds the base support contract for Merritt Island, now employs 1,489 and expects to increase this to 1,857. Bendix will experience the largest percentage increase, however. The company—under contract to perform launch support services, engineering support, materials cleaning and testing, ordnance storage and checkout, and propellant services—now has 470 employes and expects to boost this to 820.

Spinning Lunar Landing Suggested

The reaction control system for precessing the *Syncom* spin axis and correcting the satellite's orbit has been proposed for a lunar soft lander. Donald D. Williams, chief scientist of the Communications Satellite Laboratory at Hughes Aircraft Co., prime contractor for the *Surveyor* lunar lander, says model tests show that a spinning main body with non-spinning legs produces "a spectacular improvement on the ability to remain upright on touchdown."

INTERNATIONAL

Russians Held Capable of Bigger Funding

Recent announcement by the Soviet Union that it will make large outlays in development of its agricultural economy during the next five years should not lead anyone to infer that it will cut back its military and space efforts, a study by the Joint Congressional Economic Committee warns. The committee says a close analysis points to the conclusion that the USSR can continue its present intense efforts—and in addition deploy an advanced weapons system.

III-C Performance Disclosed

Early data on the June 18 launch of the *Titan III-C* at Cape Kennedy indicates that the two strap-on 120-in.-dia. solid motors ignited within 0.003 second of each other.

Burning time of the two 85-ft.-tall units was 113.0 and 113.18 seconds. The big engines developed peak thrusts of 1.2 million lbs. and 1.22 million lbs. The 37-ton burned-out cases impacted into the Atlantic 130 miles downrange some six minutes after launch.

Observers report both cases caused sonic booms during their descent and landed 6 miles apart. One case floated briefly but sank before a Navy tug could reach it. A 12-ft., 8,000-lb. pressurization tank from the thrust-vector-control system on one solid was recovered.

Engineers at United Technology Center, developers of the big solids, say that the cases probably could have been recovered if slowed by parachutes.

Lockheed Quits SRAM Contest

Lockheed has announced its decision not to compete as a prime contractor candidate for the Air Force *Short Range Attack Missile (SRAM)*. However, the firm's subsidiary, Lockheed Propulsion Co., continues to make a strong effort in promoting its pulse motor as the *SRAM* propulsion unit.

The three-pulse, dual-thrust solid motor concept thus is seeking acceptance by any of the firms entering the *SRAM* competition as primes. Both Douglas and Boeing are among the firms that are actively forming teams to bid on the program.

Apollo Abort Test Success

The degree of success achieved in the second *Apollo* pad abort test June 29 at White Sands Missile Range, N.M., may obviate future testing of the pad abort system.

Test spokesmen told MISSILES AND ROCKETS earlier that if the test were successful in proving out modifications made since the first pad abort test on Nov. 7, 1963, it would be the final such trial.

Modifications included two canards—wing-like surfaces located near the top of the launch escape system to aid in turning the Command Module forward—a boost protective cover, a jettisonable nose cone and reefed dual drogue parachutes. Main parachutes also had been improved, with diameter reduced from 88 to 83 ft. and removal of 75% of the fifth ring of sails to improve deployment characteristics.

Lockheed Propulsion Co.'s launch escape motor subsystem successfully pulled the engineering test model, provided by North American Aviation, from a special adapter that substituted for the *Saturn* launch vehicle in the test. The capsule traveled about a mile. About 11 seconds after initiation of abort, the canards deployed, turning the module forward. The entire flight took about 2 minutes and the Command Module touched down at about 17 mph.

So far, the launch escape and parachute recovery systems have undergone five successful abort tests. Two more higher altitude abort tests are scheduled.

Comsat Inaugurated

Commercial satellite communications between the U.S. and Europe opened June 28 with telephone calls between President Johnson and European government leaders over the *Early Bird* communications satellite.

Participating in the public inaugural ceremony were British Prime Minister Harold Wilson; Chancellor Ludwig Erhard of the Federal Republic of Germany; Louis Jacquinot, French minister of state; President Hans-Peter Tschudi of Switzerland; and Ramon Gaspari, Italian Undersecretary of State of Posts and Telecommunications. The messages reflected a common theme of peace through better communications.

Also participating were Lowell F. Wingert, vice president of American Telephone and Telegraph Co., and European telecommunications officials. These included Pierre Marzin of France; Richard Stuecklen, Germany; Dr. Ernesto Lensi and Dr. Carlo E. Martinato, Italy; and Anthony Wedgewood-Benn, Postmaster General of Great Britain.

Communications Satellite Corp. is presently leasing 114 of *Early Bird's* voice channels to commercial users (M/R, June 28, p. 24). AT&T is renting 74, and Radio Corp. of America, International Telephone & Telegraph Corp. and Western Union International, 10 each. Six channels are being reserved by the Federal Communications Commission for use by Canada when its ground station is completed.

Meanwhile, William Hagerty, president of the Drexel Institute of Technology, has been named by President Johnson to replace Clark Kerr on the Comsat board of directors. Kerr, president of the University of California, is resigning because of conflict of duties.

'Com Center' Pact Awarded

An electronic "communications center" for relaying target information between Army air defense command posts and guided missile installations is being developed by Martin Co.'s Orlando (Fla.) Div. under a $335,000 contract from the Army Missile Command.

Martin-Orlando will provide four experimental models of the unit (designated AN/GSA-77 Battery Terminal Equipment) and complete documentation. The four units will undergo extensive field testing later this year to demonstrate compatibility with both *Nike* and *Hawk* surface-to-air missiles and three different Army electronic fire distribution systems.

All Minuteman I's Operational

All 800 of the nation's *Minuteman I* ICBM's were declared operational last week with SAC acceptance of Wing 5 at Warren AFB, Wyo. The Warren wing has four squadrons of 50 missiles each and its operational status marks the finish of the *Minuteman I* program.

Even as it went into operation, Wing 5 was already obsolete in terms of Air Force modernization plans, which call for replacement of *Minuteman I* with improved *Minuteman II* missiles, with replacement scheduled to begin in the summer of 1966 at an estimated cost of $1 billion. Modernization replacement, which will begin at Whiteman AFB, Mo., will be followed by Malmstrom, Elsworth, Minot and Warren Air Force Bases in that order.

Only *Titan II*, SAC's non-cryogenic liquid-fueled ICBM, remains operational as a complement to *Minuteman*, with 54 in the SAC inventory. A total of 126 *Atlas* and 54 liquid-fueled *Titan I* missiles have been removed from their operational sites and are now "in storage," Air Force spokesmen said.

Telefunken Wins CSC Study

West Germany's Telefunken AG has won a contract from the Communications Satellite Corp. to study a new satellite antenna design.

Telefunken engineers say the sys

tem should provide an additional 3 db of gain, primarily by altering the radiation pattern to provide wider ground coverage for peak signal strengths. The antenna reportedly is a multiple dipole, de-spun system designed for a synchronous altitude satellite.

The contract to Telefunken, not yet announced by Comsat Corp., is one of five new studies that will be awarded to European firms or government agencies. All five, to be announced shortly, are reported to be in the $30,000-$100,000 bracket.

Bisplinghoff Leaving NASA

Raymond L. Bisplinghoff, NASA associate administrator for advanced research and technology, will leave his post at the end of August to become president of Case Institute of Technology. He joined the space agency in August, 1962. A successor has not been named.

Robert F. Thompson has been named mission director for future *Gemini* missions. Col. C. H. Bolender, USAF, will direct the first and second *Apollo/Saturn IB* flights. Both men are assigned to the mission operations organization in the Office of Manned Space Flight, NASA Headquarters.

Christopher C. Kraft, who served temporarily as both mission and flight director for *Gemini 2, 3,* and *4,* will continue in his regular assignment as flight director for future *Gemini* missions.

OTS Studies To Be Let

NASA expects to select two firms in about a month for parallel one-year design studies of the *Optical Technology Satellite* for the *Apollo Extension System.*

The contracts will be worth about $350,000 to each firm. First phase of the contract calls for a study aimed at finding out what laser and optical telescope experiments should be included in *AES.* Second calls for mission analysis and preliminary design of the *OTS* spacecraft.

Ten firms, along with various associate firms, have submitted bids.

Crippling Strike Ends at Cape

Work resumed on June 30 at Cape Kennedy and Merritt Island Launch area after a costly strike that held up already delayed construction projects at the *Saturn IB* launch pad, Vehicle Assembly Building and other major facilities.

More than half of some 5,000 construction workers had stayed away from their jobs for four working days, observing picket lines set up by members of two locals of the International Alliance of Theatrical and Stage Employes (IATSE) who struck McGregor & Werner, Inc., a subcontractor to Ling-Temco-Vought. The IATSE members, numbering about 200, operate reproduction services for NASA. They began picketing June 24. On the evening of June 29, they voted unanimously to return to work after the company agreed to participate in wage negotiations beginning July 1 in Washington, D.C.

There were no immediate estimates of the cost of the labor trouble, most recent of a series that has plagued work at *Saturn IB's* Pad 34. The pad had already slipped about five weeks from its earlier-scheduled July 2 completion target date.

Fubini Going to IBM

Dr. Eugene Fubini, deputy director in the Defense Dept.'s Directorate of Defense Research and Engineering and an assistant secretary of defense, has resigned his Pentagon post to accept a position with industry as a vice president of IBM.

Fubini is scheduled to join the

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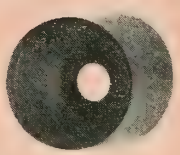

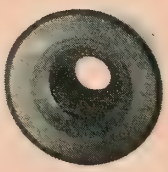

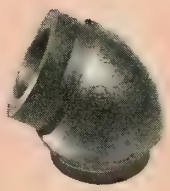

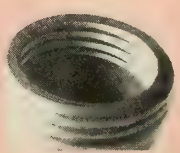

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firm officially July 19 and will direct IBM's Advanced Systems Development and Research divisions, reporting to Arthur K. Watson, senior vice president.

Scientist-Astronauts Picked

Six scientists will begin training late this month to become crew members on Project *Apollo* flights.

The scientist-astronauts, announced last week by NASA, include: Owen K. Garriott, associate professor of physics at Stanford University; Edward G. Gibson, research scientist at Philco Corp.'s Applied Research Laboratories; Duane E. Graveline, flight surgeon at the Manned Spacecraft Center; Lt. Cdr. Joseph P. Kerwin, Navy flight surgeon at the Cecil Field Naval Air Station; Frank C. Michel, assistant professor of space science at Rice University; and Harrison H. Schmitt, astrogeologist for the U.S. Geological Survey.

Michel and Kerwin are qualified jet pilots and will report to MSC at once. The other four will take a year of pilot training at Williams AFB, Ariz., before reporting to MSC.

The men were chosen from a group of 16 nominees submitted by the National Academy of Sciences. They were judged primarily on their scientific backgrounds, the space agency said.

Shots of the Week

The second *Apollo* pad abort test conducted at White Sands Missile Range, N.M., June 29 was termed a full success (see item, p. 8).

- The French magazine *Armée* reported on June 17 that the French army has carried out a *Hawk* antiaircraft missile launch in the landes region of southwest France.
- The Soviet Union has announced that it launched *Cosmos 69* on June 25. Apogee of the satellite was given as 200 miles; perigee, 126 miles. *Cosmos 69* has a period of 89.7 minutes.
- An Air Force Strategic Air Command crew launched a *Minuteman* ICBM from Vandenberg AFB, Calif., on June 29.
- Air Force Capt. Joseph Engle flew the NASA-Air Force *X-15* rocket plane to an altitude of 282,000 ft. on June 29, thus qualifying for military astronaut rating. Purpose of the flight was to obtain measurements of the Earth's horizon to establish design criteria for spacecraft navigation equipment. The *X-15* was released from the B-52 mother ship near Delamar Lake, Nev.
- A Strategic Air Command crew from McConnell AFB, Kan., launched a *Titan II* ICBM from Vandenberg AFB, Calif., June 30.
- NASA launched a 70-ft. antenna aboard an *Argo D-8 (Journeyman)* rocket from Wallops Island, Va., on June 30. Primary purpose of the shot was to measure the intensity of RF energy from outside the solar system.

Saturn System to Douglas

Douglas Aircraft Co., Inc., will produce a propellant utilization system for the S-II stage of the *Saturn V* vehicle under a $7-million contract from North American Aviation.

The utilization system will continuously measure the quantity of liquid hydrogen and liquid oxygen in the S-II and control the engine mixture so that a minimum of propellant is left at engine cut-off.

The system consists of two sensing elements connected to a computer, which compares the propellant mass in each tank and notes any deviation from the predicted burning ratio. If any fuel imbalance occurs, the computer signals a valve, which either increases or decreases oxidizer flow as needed.

NASA has also announced that it will negotiate with Douglas for nine additional S-IVB stages for the *Saturn V* launch vehicle. Cost of the contract is estimated at $150 million.

Metric System Pondered

Hearings on a bill that would set up a study to determine the feasibility of U.S. conversion to the metric system will be held July 14 by the Senate Commerce Committee, with Sen. Gale W. McGee (D-Wyo.) presiding.

A House bill, similar in intent, which was submitted by House Science and Astronautics Committee chairman George P. Miller (D-Calif.), will get an airing in August.

Reds Self-Critical

Duplication of effort, misuse of modern electronic equipment and excessive paper work were branded as major shortcomings last week in the Soviet military newspaper, *Red Star*.

The publication complained that many of the Soviet Union's military rocket units are unprepared for a space age war. The article was one of a number published recently by the paper criticizing USSR missile readiness.

INSPIRATIONAL THOUGHTS FOR THE TECHNICALLY INCLINED

ITTSY BITS

Why the baby talk? We're bubbling with happiness over our latest baby. It's the fifth generation of a native-born family, and although the smallest, it is undoubtedly the best today by virtue of its breeding. This latest offspring is the new Size 11 Shaft Encoder we have named ADAC. Now ADAC, like its ancestors, is characterized by engraved drums which are interconnected by high-speed, anti-backlash, continuous gearing and by special brushes which interrogate and read out the drum position on the run or at rest.

At this point we can almost hear you say, "So what's new about that?" It's an all-around better baby! First of all, the ADAC is a high-speed device designed to run at 200 rpm input shaft speed. It can be interrogated on a bit-by-bit basis in 1 millisecond while on the run. Even more important, it packs a lot of bits into a tiny package – for example, in a can only 1.062" in diameter and 2.355" long, you can buy a count of 16,384 bits (2^{14}). We have also included all the advantages of V scan (U scan optional) for unambiguous binary outputs and have incorporated all necessary diode logic as well.

ADAC units are available as binary encoders covering the range of 2^8 through 2^{14}. We also have BCD encoders in decimal counts to 99999 and angular counts to 359.9°. A 2^{10} gray code device is also available.

To give you a better idea of the new encoder's breeding, we think these statistics will prove helpful.

TYPE SIZE 11 UNITS

CHARACTERISTIC	BINARY	BCD
Voltage/Current	28vdc/20ma	28vdc/20ma
Interrogation	Pulsed or continuous	Serial
Readout	On run and static	
Output	Parallel	Parallel digit, serial between digits
Time Sharing	Isolation diodes are standard to permit time sharing	
Counts per revolution	126 or 256	100
Starting Torque	0.20 in. oz.	0.20 in. oz.
Accuracy	± 1 bit for any given input shaft angle	
Life	5,000,000 revolutions at 300 rpm (min)	

SUMMARY OF OTHER FEATURES

■ Solid gold alloy drums and brushes ■ In-line brush geometry ■ Continuous precision gearing ■ Flush conducting and non-conducting drum surface ■ Steel shafts and precision bearings ■ Standard Size 11 mounting ■ Isolation diodes for positive and negative logic included.

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INERTIA

Sometimes it takes a sharp push to get things going. We say we're working against inertia. At other times we pull and haul to get things "off the dime" overcoming a kind of viscous unwillingness. But inertia and viscosity can be real advantages instead of irritants. There are times, for example, when a tach generator (we make them, too) can be replaced by a viscous or inertial damped servo motor. There's been a lot written on the subject, and we're not going to discuss the obvious advantages of these devices except for the following summary and an invitation to write for more details.

TYPICAL DAMPED SERVOMOTOR CHARACTERISTICS

TYPE—VISCOUS

SIZE	8	8
Part Number	CMO 0180 450	CMO 1302 450
Stall Torque	0.26 in. oz.	0.31
No-Load Speed	5190 rpm	6200
Rotor Moment of Inertia	0.69 gm cm²	0.48
Theoretical Accel at Stall	28,600 rad/sec²	48,500
Time Constant	0.0531 sec	0 0119
Fly Wheel Damping	—	196 dyne-cm-sec
Fly Wheel Inertia	—	4.6 gm cm²
Weight	2.0 oz.	2.6

TYPE—INERTIAL

SIZE	11	15	18
Part Number	CRO 1300 660	T1310-41B	R1320-2B
Stall Torque	0.60	1.45	2.25
No-Load Speed	6000	4500	4500
Rotor Moment of Inertia	1.45	5.48	6.25
Theoretical Accel at Stall	30,700	18,700	26,000
Time Constant	0.022	0.0255	0.0185
Fly Wheel Damping	100	750	750
Fly Wheel Inertia	10	100	100
Weight	6 0	12 0	18

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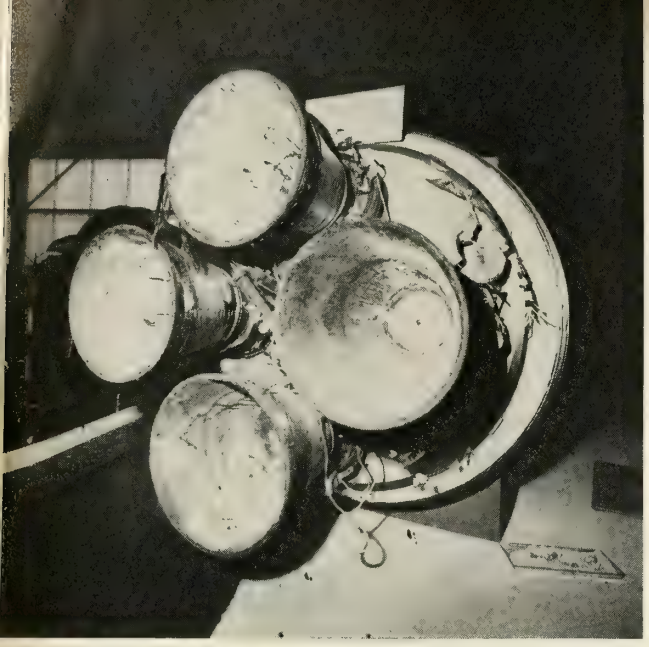
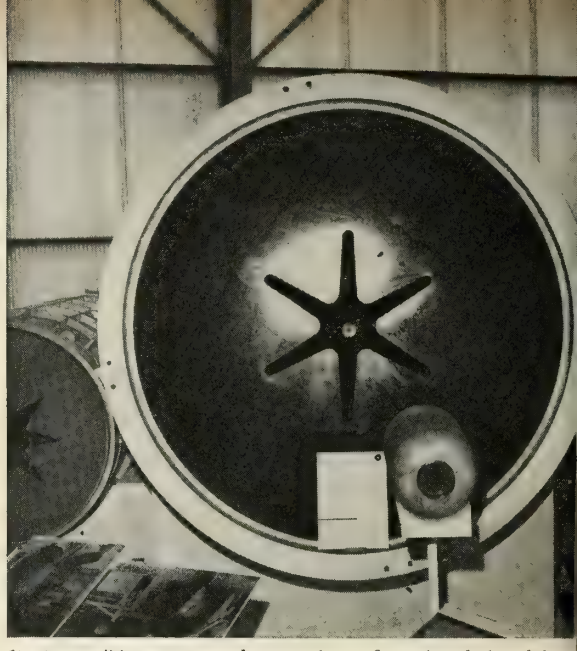




LEFT: Ablation effects from static testing show on 42-ton-thrust solid first stage for French strategic missile. RIGHT: Mockup of 6½-foot solid motor case shows grain configuration designed for 60-ton-thrust missile.

French Strategic Missile Test Set

PARIS—The ground development cycle for what is believed to be the first stage of the French surface-to-surface *Strategic Ballistic Missile System (SSBS)* has just been completed. First flight test of the stage, probably with a dummy second stage, is expected soon, according to reliable sources here. This test could take place within the next few months.

A 42-ton-thrust solid propellant stage, believed to be the same as that now in production for the *SSBS*, although it was not labeled as such, was shown for the first time at the recent International Aeronautics and Space Salon here.

The stage shown had actually undergone ground static firing about one year ago. However, flight type stages with structure different from that shown and a new actuation system for the four movable engine nozzles have also been successfully test fired on the ground. The stage is 1.5 meters in diameter, weighs 11 tons fully loaded, with 10 tons of this being propellant.

• **Diamant role considered**—The stage, experts here say, could also be used as a solid-fueled first stage for the French *Diamant* satellite launch vehicle now under development in the event the *Diamant's* liquid-fueled *Emeraude* first stage proves to be troublesome. French sources here say officially that outside of technology interchange, there is no hardware connection between *Diamant* stages and those under development for military missiles. Major funding for *Diamant* comes from the military, however.

The second stage of *SSBS* is now in development. It will also use a solid propellant, as will all French ballistic missile systems, and will probably be of the same 1.5 meter diameter.

Display of the stage by the French indicates the progress made in solid propellant technology in the past two years. At that time, the most advanced solid stage shown was the 15-ton-thrust second stage of the *Diamant*, which carries about 2.3 tons of propellant.

A look into the next generation of solid-fueled ballistic weapons was presented by the Service des Poudres, the propulsion branch of the Ministere des Armees. On display here was a mockup of a two-meter-diameter solid motor case and grain that may be intended for a 60-ton-thrust missile stage.

The unit shown was 3.8 meters long, held 20 tons of propellant, and had an 80-second burn time. Also shown was a new 1.5-meter-diameter, four-meter-long stage that held 11.2 tons of propellant in two segments. This would reportedly have a 50-second burn time. This stage could be meant as the mate for the *SSBS*.

• **Development assessed**—According to sources here, the French land-based ballistic missile program is about in the same stage of development as is the underwater-launched *Polaris*-type missile program aimed at filling the French requirement for three 16-missile-firing submarines, the first to be delivered by 1970. Underwater missile ejection tests were carried out about a year ago. The two missile programs are said to be distinctly different. They do not use the same stages, for example, although they do have many aspects in common; more so than the U.S. *Minuteman* and *Polaris* solid-fueled missiles.

Also slated to be fired soon is the French *Saphir* two-stage experimental vehicle. *Saphir* is one of several so-called technology acquisition launch vehicles the French are counting on to learn more about in-flight missile separation technology, re-entry dynamics, engine control in the high-vacuum environment, and optimum delta-V consideration.

The approved 1965-70 French weapon systems program calls for expenditure of $1,085 billion on strategic missiles during the six-year period. This provides for production and deployment of the *SSBS* and development and production of the submarine-based strategic missile.

The French Air Force expects to have 200 surface-to-air and surface-to-surface tactical missiles in hardened sites, with a complete command and control network, by 1970. There will be two launch brigades for each of these missile categories. ■

Voyager Procurement Plans Uncertain

JPL confirmed as program director for lander; space agency requests proposals for experiments to be part of 1971 flights

by Hal Taylor

REQUESTS for proposals for program definition of the *Voyager* landing capsule will not be issued until after Sept. 1.

Target date for the first step in the development of the capsule was learned as NASA announced officially that Jet Propulsion Laboratory would direct the program. (M/R, May 3, p. 14).

At the same time, the space agency asked scientists to submit proposals for experiments to be conducted during the *Voyager* spacecraft's scheduled 1971 flights to Mars.

Just how the procurement plan for the landing capsule will proceed still has not been decided by NASA headquarters.

It is possible that it may be handled in the same way as procurement of the *Voyager* spacecraft, which calls for a two-phase project definition effort before a hardware contract is awarded next year. Currently NASA is considering two other methods for the landing capsule. One would shorten the program definition effort to only one phase, thus permitting an earlier start on hardware development.

This course is favored by some officials because the landing capsule development schedule is about six months behind the spacecraft timetable. They would like to speed up the landing capsule to ensure that both space vehicles will be ready for the 1971 launch opportunity.

Exact nature of the third possible procurement plan is not known, but it probably calls for more in-house program definition work before hardware is approved.

Officials of the Office of Space Sciences and Applications expect to spend the next two months studying the various proposals before a final decision is made. As a result, the first RFP's will be delayed at least until after the first of September.

● **Experiments**—The NASA announcement said proposals for scientific experiments in a preliminary form must be sent to the agency by Aug. 15. Spacecraft and mission specifications will be defined further and furnished to potential flight experimenters about Sept. 1. At that time complete and final proposals will be invited—with a deadline for submission of Nov. 19.

Among the general areas in which NASA believes experiments may be needed on the orbiter spacecraft are atmosphere studies, such as chemical composition, temperature and pressure and their diurnal variations, and circulation patterns; planetary studies, such as gravitational and magnetic fields, and mapping in the visible and infrared topography; and planetary environment studies, including the radiant energy spectrum, charged-particle energy and density, and planetary micrometeoroid flux.

Among the likely landing capsule experiments are complete chemical analysis of the atmosphere and measurements of the vertical temperature, pressure profiles and wind velocities. The agency also hopes to get data on the chemical composition of the Mars crust material and its mineralogy, seismology, touchdown dynamics and radioactivity.

● **2-3 days on Mars**—The RFP for the experiments also gave the following details on the spacecraft and lander. The spacecraft will have an orbiting lifetime of six months and the capsule will have a two- to three-day life on the Martian surface.

There will be 7 cu. ft. and about 200 lbs. of weight available for experiments on the spacecraft, and 2 to 4 cu. ft. and 50 to 100 lbs. available on the landing capsule.

Other details of the orbiter spacecraft included the fact that it will have on the average 50 watts of power available for experimens during its lifetime, and it will be able to transmit 1,000 data bits per second.

The landing capsule will have 25 to 50 watts of power available for experiments and be able to send data back to Earth at the rate of 10 to 100 bits per second through the use of a relay transmitter which probably will be located in the orbiter spacecraft. ■

NASA Urged To Use Titan III-C

THE SENATE Appropriations Committee, in an unusual action, voted to award NASA an unrequested $10 million for work in adapting the Air Force's *Titan III-C* booster to fit the *Surveyor* lunar landing vehicle.

Echoing the fears of the House and Senate Space Committees that the long-delayed *Centaur* vehicle will not make the schedule set for the important *Surveyor* mission to conduct forays on the Moon in time to provide useful inputs for the *Apollo* mission, the committee said it was concerned because no provision has been made for a backup vehicle. It said it took its action in view of "the numerous difficulties encountered" in *Centaur*.

Total appropriations voted by the Senate committee for Fiscal Year 1966 for NASA were $5.19 billion. This figure is $69.6 million less than the original NASA budget request of $5.26 billion, but $30.3 million more than the House-passed appropriations bill.

In research and development funds, the Senate committee recommended $4,536,971,000, which is the full amount allowable under the authorization bill passed by the House and Senate Space Committees and approved by the two chambers. The Senate R&D figure represents a restoration of $15.9 million to the House bill. It falls $38.9 million below the space agency's original budget request.

The Senate committee's construction figure is $2.37 million more than that of the House. Total construction funds authorized and voted by the Senate committee are $62.37 million, $12.3 million less than the budget estimate.

Administrative operations were voted $591 million, $12 million more than the House but $18.3 million below the budget request.

In the only other specific action on provisions of the bill, the Senate committee recommended inserting a general provision that would permit NASA to finance common use materials, supplies and services from one appropriation, but later charge them off to the fiscal year appropriation when actually used.

Mathews Outlines GT-5 Flight Plan

Extravehicular activity may not be tried because of difficulty GT-4 astronauts had closing hatch; rendezvous attempt stressed

HATCH-CLOSING difficulties encountered by the astronauts after Edward White's successful 20-minute space-exercise during *Gemini 4* may preclude further extravehicular activity (EVA) until *Gemini 6*, MISSILES AND ROCKETS has learned.

Charles W. Mathews, *Gemini* program manager, said "We plan to improve the actuating latch. The latch did work when we got it back, but in exercising it to duplicate the problem White and McDivitt encountered in orbit, we created additional malfunctions. We plan to make a number of changes."

He indicated that these changes would probably not be incorporated before the *Gemini 5* flight.

The *Gemini 5* mission, now extended to a little more than eight days to equal the length of a lunar mission, will limit attempts at rendezvous to an exercise with a rendezvous evaluation pod (REP), which will be ejected from the spacecraft adapter in orbit (M/R, June 28, p. 22).

Mathews said there were no plans to stay with the booster second stage during *Gemini 5* as was attempted by McDivitt during the last mission.

"We are trying to get prepared for the *Agena* rendezvous mission on *Gemini 6*," Mathews said. "The pod is really the only thing that is equipped with the beacons with which we can interrogate the radar. The purpose of the pod exercise is really to check out all the rendezvous equipment."

● **Most important aims**—"We consider the REP the number two objective of the flight," he said.

"We are doing two things on the flight: during the wet-mock simulation flight, we will count the *Agena-Atlas* down along with the *Gemini* spacecraft and its launch vehicle. The *Agena* will be fueled for wet-mock, but not fueled for launch."

Mathews explained that there has always been some problem with the first vehicles, especially in getting procedures straight. The simultaneous count also represents a very big load on the Eastern Test Range. "They have never done this before," he said.

"We think we will probably have a few things to learn and to rectify before we can launch," he explained.

Difficulties with the *Atlas-Agena* during the simultaneous count will not hold up the spacecraft launch, he said. The *Agena* work will continue and the crew will work at ironing out any problems before disassembling the *Atlas-Agena* vehicle.

The same tankage is carried for all long-duration missions, and two extra tanks of maneuvering fuel for *Agena* rendezvous missions are added.

Mathews said that extra tankage of maneuvering fuel required for all *Agena* rendezvous and docking missions will not be carried aboard the *Gemini 5*. This is to make room for oxygen needed for the eight-day mission and for extra attitude-control fuel.

● **Modification considered**—He said that a change may be incorporated into the spacecraft after *Gemini 6*—the installation of two maneuvering (i.e. translational) controllers in the cockpit to enable both pilots to maneuver the spacecraft into the *Agena* docking collar.

In the present spacecraft configuration, only the command pilot can operate the maneuvering controller, which is at his left. The attitude controller, however, is located on the center pedestal and is accessible to both pilots.

"We feel that training is required in this area, especially for the astronauts we commit to the *Apollo* mission. This would give us the opportunity to train more than one man on the same flight."

Mathews said there are no formal plans to launch two spacecraft during one mission, although he admitted that it is possible. About the only thing it would demonstrate is the capability to deliver flight-ready spacecraft from McDonnell, Mathews said. There is only one *Gemini* pad and a second launch during a mission already in progress would not be possible because of the pre-launch checkout time needed.

He also discounted the possibility of having both pilots emerge from the spacecraft on any future mission in the *Gemini* program. "Although we would want cooperative efforts in space to assemble structures, we have nothing in the mill for this type of activity during *Gemini*," he said. ■

Aerojet Successfully Pulses Hybrid Rocket

HYBRID rocket engines may find applications as auxiliary propulsion units as a result of an on-command pulse demonstration by Aerojet-General Corp. The experimental high-energy hybrid model pulsed at the rate of 10 times a second.

The demonstration represents the first known pulsing of a hybrid propulsion device of any size. The tests were conducted at Aerojet's solid rocket plant in Sacramento, Calif., under the direction of NASA's Marshall Space Flight Center.

The program is essentially a study and the tests were run to demonstrate that hybrids could be pulsed. The current design used a cryogenic liquid oxidizer and a metal hydride solid grain—developing a sea level specific impulse of 346 seconds. This means an Isp of about 417 seconds at altitude.

The key to the pulsing operation is a precisely machined valve developed by Aerojet-General and an outside vendor.

T. C. Bowden, Aerojet's program engineer, told MISSILES AND ROCKETS the current design should work equally well with any of the storables under consideration for hybrid systems. As secondary propulsion, hybrids offer the same advantages over other modes as in primary propulsion applications.

The program, funded by Marshall, is aimed at defining a basic, multi-functional hybrid propulsion system for use in a number of different missions on a variety of vehicles with little or no modification.

U.K. Industry Awaits Review Findings

Four government studies nearing completion could lead to expanded efforts; Bondi Committee may be key to increasing space program

LONDON—British space, defense and electronics firms—some badly shaken in recent months by cancellations in major aircraft projects and all facing uncertainties as to the future posture of their industries—are anxiously awaiting completion within the next two or three months of several government-initiated reviews.

It is hoped that these studies will lay the groundwork for government decisions on the need for a national space program to complement efforts in international cooperation, the role of the military in British space plans, the future size and optimum role of the aviation industry, and the best way to ensure progress in the electronics industry.

Four major reviews are under way: the Plowden Committee's review of the aviation industry; the Bondi Committee's review of U.K. military space potential; the newly created Space Research Council's review of civilian space matters; and the efforts of the likewise newly established Ministry of Technology to foster the growth of advanced technology in several broad fields.

Of the four groups, the Bondi Committee probably is the key to an expanded British space program. One of its assignments is to recommend as to the feasibility of developing a U.K. launch vehicle. Plans for such a development, based upon a larger-diameter version of the *Black Knight* re-entry research rocket with a variety of upper-stage configurations, were inherited by the Labor Government from its Conservative predecessors.

A decision to proceed with such a project would open up several possibilities.

● **New routes**—For one thing, the committee is believed to be studying the potential of a series of technological satellites in the 200-300-lb. class, to be developed by the military and used as orbital test beds. There also is interest in U.K. military communications satellites. Buying launch vehicles for military purposes from NASA or ELDO (European Launcher Development Organization) might create some public relations problems for the vendors.

Furthermore, availability of a British launcher would allow expansion of the U.K. civilian spaceflight program now being studied by the Science Research Council, a group created in an April reorganization aimed at improving administrative functioning in these areas. Additional satellites are under consideration.

Basically, the British problem is technology—how to advance it fast enough and far enough in several fields so that it can both aid domestic progress and improve the nation's badly deteriorated international export position.

To accomplish this in the face of the austerity imposed on expenditures in these areas by the Labor government since it took office last fall—and a resultant lack of long-range investment confidence in portions of the industry—will demand some major new positive action by the government.

Observers here say Prime Minister Harold Wilson is well aware, nevertheless, that advanced technology is vital for the future welfare of the United Kingdom.

Cancellations of multimillion-dollar aircraft programs—three in recent months—in favor of large-scale buys of already developed U.S. aircraft may have been reasoned judgments on the part of the government. However, they have had the undesirable side effect of reducing the amount of advanced research, which was being supported by those firms hardest hit by production cut-backs. There is still not a crisis in industry because of this, but there is a feeling that instability will develop unless the government soon gives a detailed explanation of how it intends to either replace some of that business or provide new markets for similar technology.

● **Space answer?**—To several company officials, the answer lies in a major investment in a national space program. "An expansion in British space activities to levels 4-5 times their current size is essential to provide the spearhead of technological advance," says chief scientist W. R. Thomas of Elliott-Automation Ltd.

"The advantage," he maintains, "is that it provides this advance in so many technologies. Programs such as communication satellite projects will also generate new commerce directly. We must have some idea, for example, of what the government is prepared to do to aid British industry in building up competence in this field so that we are able to compete successfully for the new business."

Thomas, however, like some other industrial officers interviewed by MISSILES AND ROCKETS, is not unduly critical of the government at this point. "Perhaps it is unfair to criticize government inaction because of our present balance of payments crisis. Once we are out of this position, then we can argue priorities based on more sound technological sense."

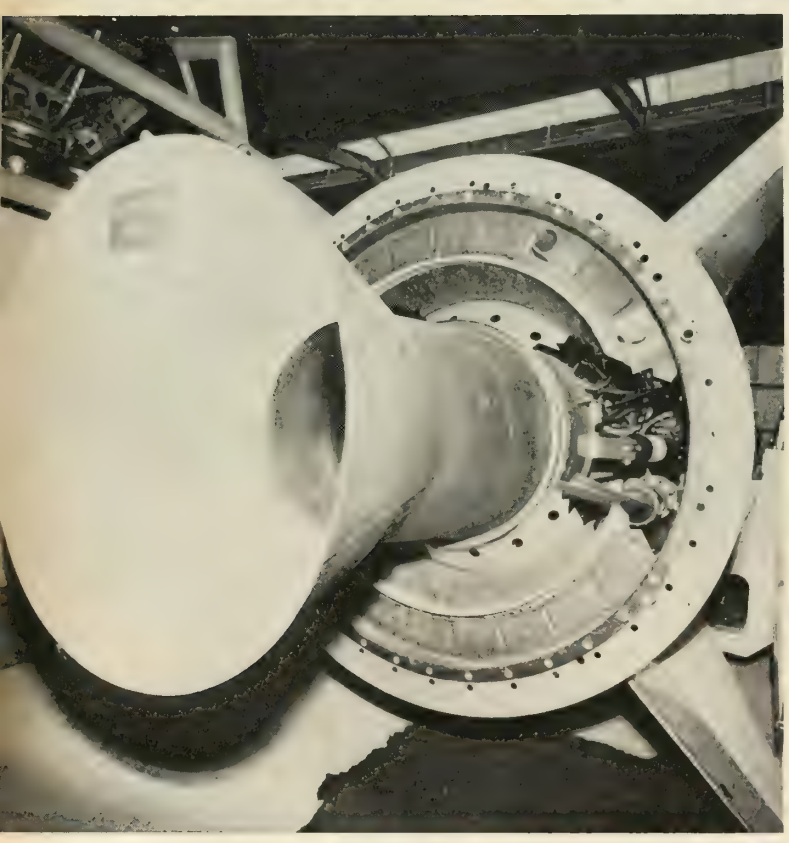
A similar view is held by project planner Ronald Staines of Hawker Siddeley Dynamics. "We believe that reason must prevail ultimately. On the surface there appears to be a good case for chopping what initially look like strictly prestige-type aerospace projects, but a closer look in a calmer environment indicates just how extremely important the engineering feedback is. Can a country such as ours, which depends upon its technology to export, say that we can't afford it?"

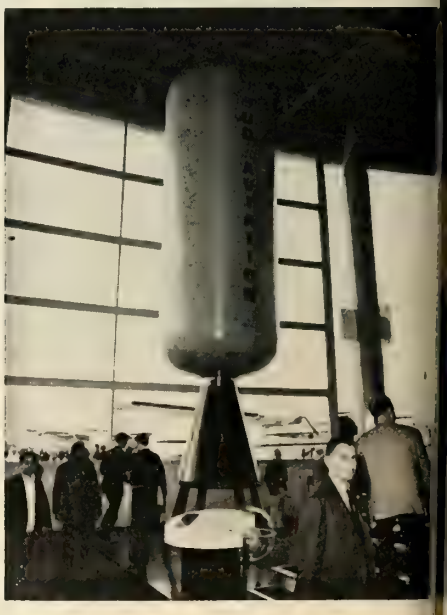
● **Sine qua nons**—Whatever budgetary decisions may be forthcoming from the government, several industrial representatives interviewed by M/R outlined some fundamental changes that are needed:

—Firm objectives in defense and space affairs must be stated clearly, quickly, and confidently by the government so that the industry can set up economical long-range planning and investment in new facilities and research undertakings.

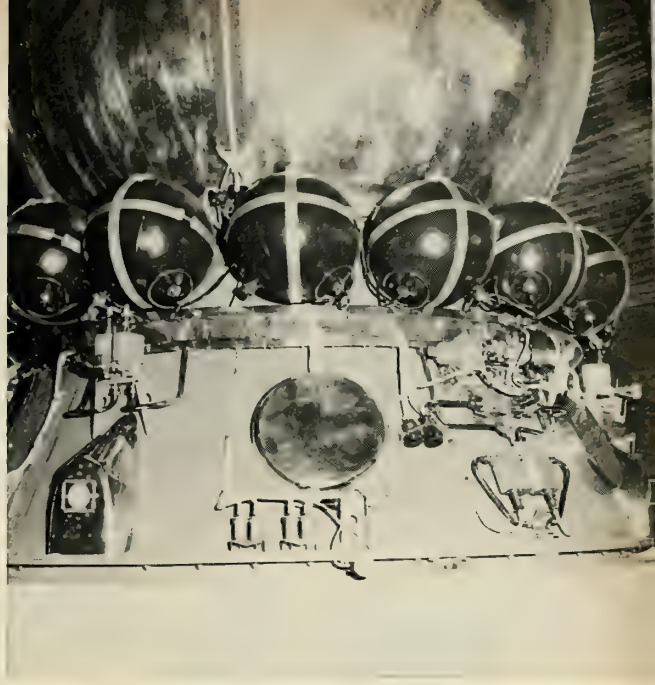
—Quality and accessibility of vital statistics on projected government expenditures and the spelling-out of intended areas of support must be improved. "Statistics in the U.K. are appalling," said one industry trade association leader, "especially in the military and space field. It is virtually impossible to keep tabs on the market or the health of an industry."

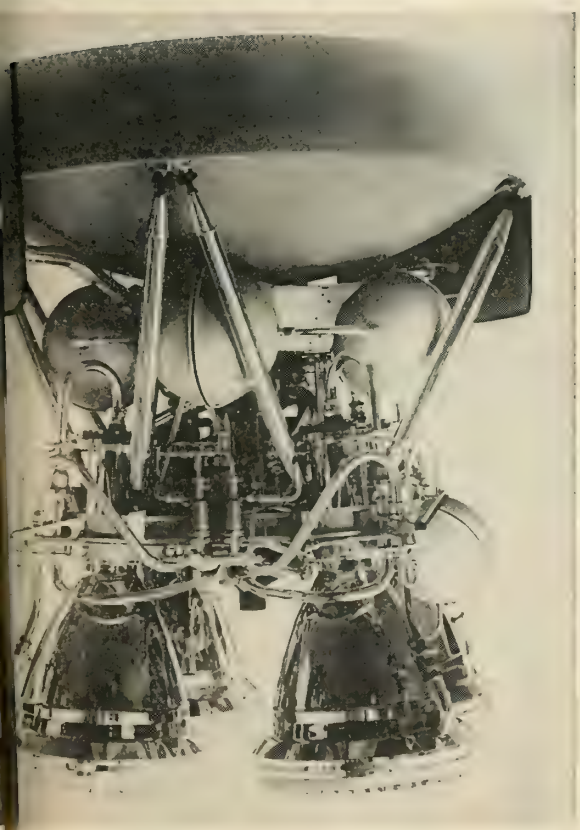
—There should be a reduction of the detailed design authority exercised over projects by the responsible U.K. government installations, and a corresponding increase in the industry's capability to develop greater skills in total systems design and engineering. Industry's complaint is that it is treated too much as builders and full use is not made of its resident talent. ■





Europeans Display Significant Progress in Space At Paris Air Show





MISSILES AND ROCKETS PHOTOS BY MARTIN HOLZAPFEL

Page 16: Unusual strap approach was shown on German hird-stage tankage for ELDO booster by developers Entvicklungsring Nord and Boelkow GmbH (*upper left*). Nozzle for this stage also was on display (*upper right*). *Emeraude* liquid-fueled first stage of French *Diamant* three-tage rocket carries 27,500 lbs. of kerosene and nitric acid xhausting through single nozzle configuration (*lower left*). EREB's two-stage *Rubis* rocket, of which the second stage ill be the *Diamant's* third stage, recently chalked up three uccessful firings, now is considered operational (*center ight*). Sud-Aviation disclosed a glass-filament-wound solid-motor rocket case holding 28 tons of propellant, largest yet built in Europe (*lower right*). **Page 17:** Unusually clean configuration was evident on 40-lb.-thrust vernier engine for German ELDO third stage (*upper left*). New SEPR high-energy upper stage uses liquid hydrogen and LOX to produce 3,300 lbs. of thrust from each of four nozzles (*lower left*). Close-up of Soviet *Vostok* shows life-support pressure bottles at junction of re-entry sphere and service module (*upper right*). Short Bros. & Harland *Tigercat* surface-to-air missile, land-based version of *Seacat,* has been selected by Royal Air Force for airfield defenses (*lower right*).

MISSILE/SPACE ENCYCLOPEDIA

The Ninth Annual World Missile/Space Encyclopedia provides year-round selling action with one low cost ad. It's the industry's year-round reference manual for data on U.S. and foreign missiles, spacecraft, sounding rockets, rocket engines and space systems. The Missile/Space Encyclopedia provides a unique showplace to maintain year-long contact with an effective audience of over 53,000* leading scientists, engineers, designers and management men — the people making the important defense/space buying decisions.

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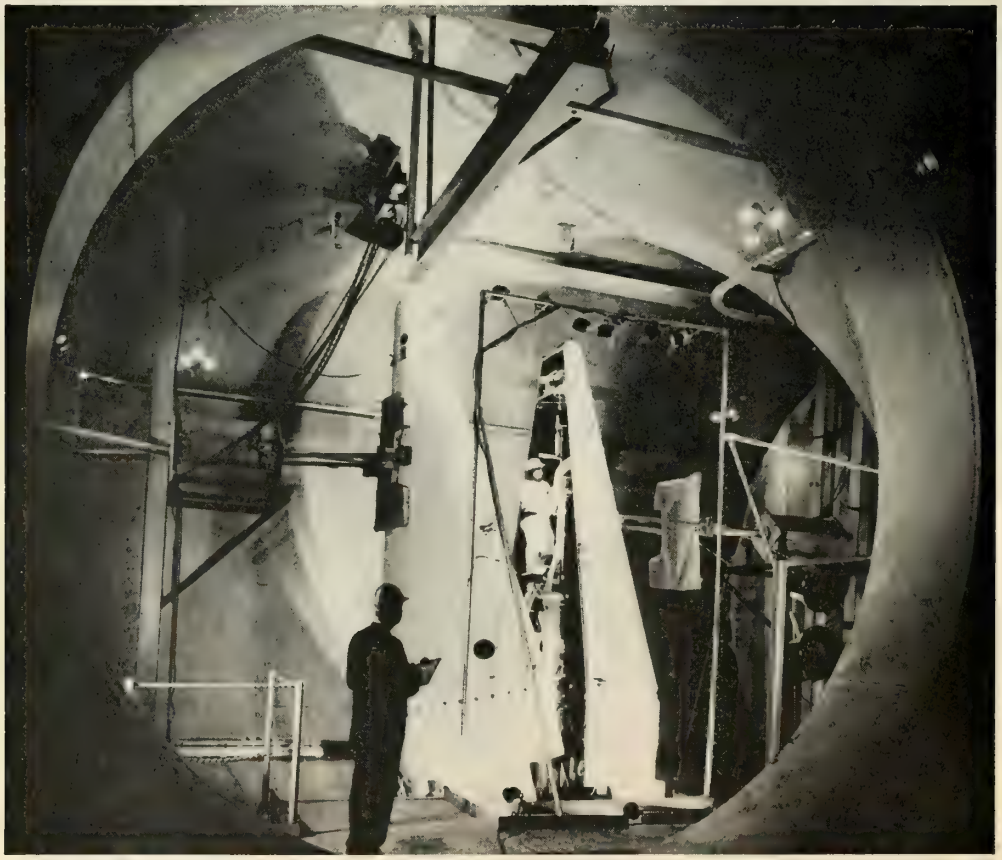
U.S. SPACECRAFT: SCIENTISTS CHECK SURVEYOR IN PROTECTIVE SHROUD IN TEST CHAMBER



missiles and rockets

The Weekly of Advanced Technology

1001 Vermont Ave., N.W., Washington, D.C. 20005

Technical Countdown

ELECTRONICS

Satellite Observations Rise

Satellite observations processed by North American Air Defense Command's Space Detection and Tracking System have risen to 350,000 per month compared with 209,000 per month a year ago. Although the increase is chiefly due to growing space traffic, it also reflects improved space surveillance. The space object number has now reached 1,415, with 613 objects still in orbit. Of these, 161 are payloads: 134 belong to the United States, 23 to the USSR, 2 to the United Kingdom, and one each to Canada and Italy. The U.S. and the USSR each have seven deep space probes somewhere in the solar system.

Students Design Effective Satellite

A Polar-Orbiting Satellite System—University of Michigan (POSSUM), designed by a summer semester engineering class, has the potential of improving weather satellites at half the cost. *POSSUM* would be a 234-lb. package of TV cameras and a high-resolution infrared radiometer boosted into an essentially circular polar orbit 340 mi. high by a four-stage advanced *Scout* rocket from the Western Test Range. The proposal and 118-page report drawn up by 18 seniors and 4 graduate students impressed industry observers with its competence and the speed with which it was developed. The toughest part of the job was computing orbital parameters, but the students had the help of the computing unit at Ling Temco Vought. A more detailed analysis will be available in August says student project manager Donald Dieck.

Radar Best For Planet Orbits

Stressing the extreme accuracy of inter-planetary radar measurements, Dr. Thomas Gold, Director of the Cornell University Center for Radiophysics and Space Research, predicts that all planetary orbits that can be computed from radar will use this method instead of the optical techniques currently in use. Gold told the 10th Air Force Office of Scientific Research seminar at Cloudcroft, N.M., that measurement of Mercury's orbit by radar showed large errors in predictions made from optical measurements—including deviations of up to 5 milliseconds in the time of return of the radar echo from the planet. Gold said a careful examination of the orbital computations was called for to see whether the deviations were merely due to errors in assessing planetary perturbations or whether some unsuspected physical effect was present.

Broad Band Radiation Source Forecast

Sources producing kilowatts of radiant energy spreading from microwaves to soft X-rays were forecast by Dr. Benjamin Lax, Director of the National Magnet Laboratory. Speaking at the 10th AFOSR Seminar at Cloudcroft, N.M., Lax said that combining a 100-mev electron accelerator and a 100-kilogauss magnet would provide a kilowatt of radiation with wavelengths extending from 100 Angstroms to 10 cm. The accelerator would inject electrons into a storage ring several feet in diameter to build up a circulating current of one ampere. When this current is brought into a small high intensity magnetic field the broad band radiation will appear, said Lax. Chief problem will be getting the electron current into the field, he admitted. He thought various combinations of electron energy and field strength could be selected to produce the radiation.

British Firm To Produce SIC's

Elliott-Automation, Ltd., in England, reports it will be turning out first quantities of silicon integrated circuits from its new plant in Scotland in about two months. Initial devices will be produced under license from Fairchild Semiconductor Div. of Fairchild Camera & Instrument Corp. However the firm says it will also produce circuits of its own design, both digital and analog. The circuits will be for both internal use within Elliott products and for external sale. The firm told MISSILES AND ROCKETS that by the end of the year it will be turning out 10,000 circuits a month, and 1 million a month by 1968.

CRYOGENICS

Air Liquide Expands Cryogenic Research

A 400-man Cryogenics Study Center recently opened near Grenoble in Southeast France by Air Liquide will conduct across-the-board applied research and prototype engineering in the whole field of low temperatures. Special effort is being devoted to the development of methods in the working and forming of high-strength, lightweight alloys. The loading and consumption of liquid rocket propellants and the use of cryogenic fluids in gyros and inertial guidance systems will be investigated. Insulation studies and the use of very high vacuum piping is in the works, along with cryogenic applications to nuclear reactors. The electronics and physics areas will be pursued by the group. The activity in space research and engineering at the center is largely due to Air Liquide's president Jean Delorme's interest in this field. Delorme is also head of Eurospace.

MATERIALS

Time-Dependent Materials Behavior Studied

An exploratory investigation into the time-dependent mechanical behavior of composite materials will be conducted by the TRW Materials Technology Dept. of TRW Equipment Labs. Information on the behavior of composite materials destined for structural applications under conditions similar to the final application is needed. In the case of composite materials consisting of a high-strength/low-modulus ductile matrix, there is practically no information on the time-dependent fatigue and creep behavior under service conditions. The $34,264 contract from the Air Force Materials Lab will probe this area.

SPACE MEDICINE

Dehydration Cuts Acceleration Tolerance

Douglas Missiles and Space Systems Group has demonstrated in tests run on its centrifuge that dehydration causes a decrease in human tolerance to positive acceleration amounting to 15% to 18%. Study was conducted in an effort to understand the causes of the orthostatic hypotension which has affected several of the astronauts—most markedly Walter Schirra and Gordon Cooper—after their spaceflights.

NASA May Aid in French Program

Scout launch vehicle considered to substitute for Diamant; D-3 satellite would 'harvest' weather data from balloons

by William S. Beller

FRANCE'S PROJECT Eole, designed to send hundreds of balloons aloft to get synoptic upper atmospheric data—to be picked up by satellite—may be accelerated through a cooperative arrangement now under study at NASA.

France originally intended carrying out the Eole experiment, which could lead to global, long-range meteorological forecasting, through its own efforts. Sometime in 1967, a *Diamant* rocket was to launch the Eole satellite, known as *D-3*, into a near equatorial orbit.

If NASA agrees to furnish a *Scout* vehicle to launch the *D-3*, as it is considering doing, France could possibly cut a year or more off its timetable, as well as some expenses.

The first development launch of the *Diamant* is expected late this year or the beginning of next from Hammaguir, Algeria. If, as in many ambitious space programs, the early attempts are not successful, then a *Scout* launch of the *D-3* would fulfill France's scientific planning. Otherwise, the *D-3*, already under development, would gather dust while awaiting the *Diamant*. This reasoning may be behind France's present willingness to discuss a cooperative arrangement with the U.S.

• **A global understanding**—The Eole experiment is based on a simple premise: if the state of the Earth's atmosphere up to altitudes where weather is made were known through enough data points, then long-range weather predictions could be made.

The experiment is also founded on the belief that there is enough understanding of the physical processes going on in the Earth's upper atmosphere to derive a creditable mathematical model of the dynamics of the whole atmosphere.

Yet, until there are extensive and simultaneous atmospheric data to work with, such a model cannot be checked out or refined. This is where the science of long-range weather prediction stands today. Project Eole will attempt to wed observations to theory.

For this purpose, observations of a limited geographic scope are useless. This is the feeling of the French space agency (CNES), sponsors of Eole. The reasoning was clearly stated by Pierre Morel, until recently the director of programs for CNES, and now a consultant to the agency and an associate professor at the University of Paris.

Morel said: "Attempts at long-range understanding of weather evolution over a limited area are bound to fail since the weather after a few days will be largely determined by travelling perturbations coming from far outside this area."

• **The program**—The Eole experiment will be only the first step in trying to show that a relatively inexpensive, yet practical, means can be devised to get the needed atmospheric data.

The experiment will be considered successful if through it basic meteorological data can be collected by a satellite and balloon system using 1) a large number of constant-level balloons and 2) an Earth-orbiting satellite that periodically identifies, interrogates and locates each balloon.

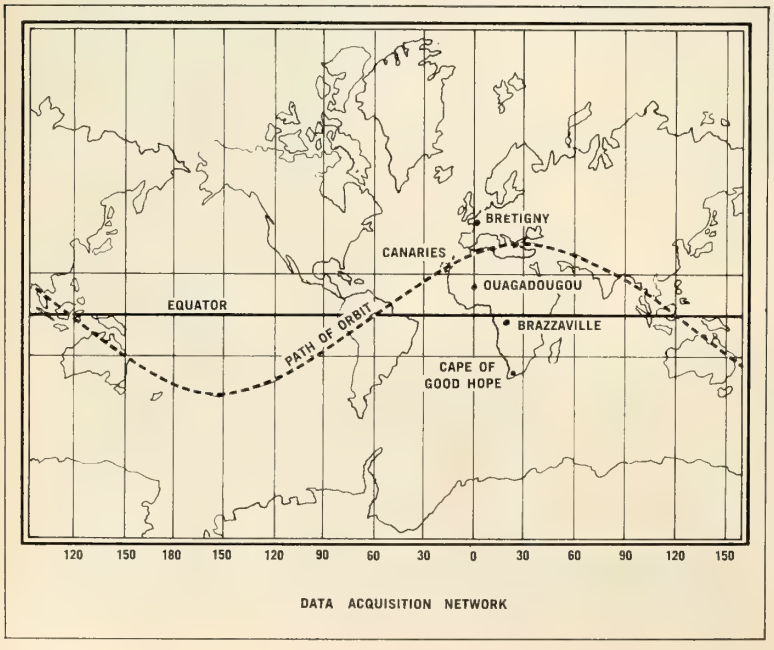
The balloons will be used to measure the velocity and direction of the average wind, local pressure and local temperature.

The balloons themselves will be the sensors for the movement of the winds. The orbiting Eole satellite with appropriate ranging equipment on board will presumably be able to accurately locate the balloons with respect to the satellite's trajectory.

The pressure and temperature data telemetered from the balloons, as well as their location data, will be recorded in the satellite memory for later transmission to ground stations.

Because the Eole experiment is

PROPOSED PATH of France's D-3 satellite in Project Eole. The satellite would be used in conjunction with upper atmosphere balloons for global weather forecasting.



simply one to see if the idea has any value, no attempt will be made to get anything like a full global coverage of the Earth's atmosphere. Nor will any provision be made to send the collected data to a receiving station on a real-time basis.

The coverage will be restricted mostly to the oceanic areas in the Southern hemisphere where airline traffic is relatively small. In the first phase of the experiment, about 500 balloons will be launched at one atmospheric level in a zone extending around the globe and running from the equator to 60° south latitude.

If all goes well, plans call for launching another 500 balloons at several atmospheric levels within a restricted area in the equatorial belt extending from 20° north latitude to 20° south. The three pressure levels considered are 800, 500 and 200 millibars.

The goal of Eole is to get a complete set of observations of the troposphere, within geographic limits for a period of at least a month. A truly dense set of measurements would be needed for a comprehensive description of the state of motion of the atmosphere, but the Eole data should be sufficient for "reasonably accurate weather forecasting for 10 days or so," said Morel at a recent scientific meeting.

• **The balloons**—Superpressure balloons will be used since they tend to remain at a fixed altitude over a relatively long period of time. Conventional mylar laminates may be used for the balloon material, but there is a possibility that scrim-reinforced polyethylene fabric might do better. Morel says that French concerns are studying and developing several of these envelope materials.

Regardless of which is chosen, the balloon system will consist of a small envelope inflated to a maximum (and therefore constant) volume of about 15 cubic meters and an instrument payload. In turn, the payload will be made up of a power supply package and a transponder and sensor package.

Although these two packages must be reliable enough to function for at least a month, the Eole experiment itself will last about three months. The balloons are expected to travel 500 to 2,000 kilometers per day, depending on their altitude. Consequently, in order to avoid crowding the atmosphere or exhausting the energies of balloon launch crews, no more than two balloons a day will be scheduled for launch from any individual station. About 20 stations distributed in the Southern Hemisphere will be needed to launch the 500 or so balloons in "a reasonable two-week period," said Morel.

• **Payloads**—The balloon power supply will have to put out an average of 50 milliwatts with eight watts peak during short transmission periods. Morel said that one possible solution consists of a solar cell generator (three units of 30 solar cells each) delivering 600 mw under the best lighting conditions and a nickel-cadmium battery. "Two hours of good light will then be sufficient to operate the device continuously, even during the night," he said.

He drew attention to the fact that storage batteries usually cannot operate at low temperatures, and therefore a very good thermal insulation would have to be provided to protect them. For this reason, "thin-film batteries usable at low temperature are currently under development." These could eliminate the need for thermal insulation and would therefore be lighter and require less bulky packaging than the older batteries.

On the other hand, the RF and digital equipment can be very lightly packaged. Morel sees no need for thermal protection. A preliminary estimate of the electronic package weight is about one kilogram, which includes a 100-gram antenna.

A thermistor thermometer and a pressure gauge make up the sensors. A sunshade will protect the thermistor from direct sunlight and raindrops. Should the problem of wetting and icing of the bead by condensation appear serious, a warming subsystem will be included in order to dry the temperature sensor before taking a measurement.

The pressure sensor will be made up of a miniature aneroid capsule with a strain-gauge transducer.

• **Electronic systems**—The electronic systems must be small and light enough not to damage an aircraft even if the equipment should be ingested by jet engines or hit by whirling propellers. These considerations were implicit in the design of the payload packages.

The distance from satellite to balloon is computed from the round-trip time of an electromagnetic signal transmitted by the spacecraft and returned by the balloon transponder. The accuracy of such a system is best when the highest possibly frequency for the signal is chosen.

In view of the limits of conventional solid-state electronics, the best compromise frequency is about 400 mc, according to Morel. He says that even here, practical transistorized equipment cannot be found powerful enough to transmit enough RF signal for straight radar operation. Therefore, the design of the location system is based on correlation techniques and long pulses in order to keep the RF power of the balloon transponder at a reasonable two-watt level.

Morel says the job can be done by time-sharing a single RF channel in the 400 to 401-mc band. This requires that the phase information be preserved in the transponder: the return signal sent back by a particular balloon must be phase-coherent with the interrogation signals received by the balloon.

The satellite memory is described as consisting of a magnetic core register. It is searched step-by-step the same way as a magnetic drum memory. Erasing occurs only when old data are replaced by new. This memory is read out rapidly on command from ground stations.

The storage capacity of the memory was determined according to the following specifications:

—Data are transmitted to the ground every second orbit.

—When 512 balloons are all in the air, the number of return signals recorded into the memory is limited to three per balloon.

—Distribution of the balloons is uniform over the entire hemisphere.

The telemetry channel used will be the same as the housekeeping data telemetry channel. Transmission of the housekeeping data is stopped during read-out of the digital memory, which takes 100 seconds. Morel says this read-out is not destructive: the data stored in the satellite memory can be effectively read out several times. The data are erased only when they are displaced by further data collection.

Determining the actual location of a balloon from balloon-to-satellite range data is subject to three main sources of error: 1) uncertainty in satellite position; 2) in the force and direction of the wind; and 3) in the range measurement itself. By taking three successive range measurements of each balloon—at 131-second intervals—during each pass of the satellite, Morel expects only a 4-km uncertainty on the position of the answering balloon. ■

SUMMARY OF INTERROGATION LINK PERFORMANCE

	Satellite-Balloon *link*	Balloon-satellite *link*
Transmitted power P	+ 16 dB/w	+ 4.2 dB/w
Antenna gains G_1 G_2	+ 6 dB	+ 6 dB
Propagation attenuation A	−152.7 dB	−152.7 dB
Boltzmann constant K	+228.6 dB	+228.6 dB
Noise temperature T	− 28 dB	− 29 dB
Bandwidth B	− 47.8 dB	− 36 dB
Circuit losses (switches, duplexer, etc.)	− 1 dB	− 1 dB
Polarization losses	− 3 dB	− 0.2 dB
Fading	− 6 dB	− 6 dB
Safety margin	− 3.1 dB	− 4.9 dB
Signal-to-noise ratio	9 dB	9 dB

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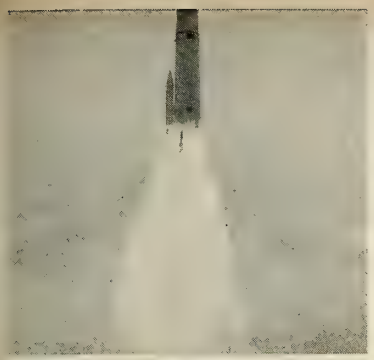

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Physicists, Chemists, Engineers
Fundamental research in field of ultra-high vacuum adhesion.

Solid Propellant Systems Engineers
Rocket motor and ballistics and motor optimization trade-off studies.

Aero/Thermo
Heat transfer and fluid mechanics for thermal analysis of booster and space vehicle systems.

Life Support and Environmental Control
Design analysis integration development and or Fortran experience.

Electrical Engineers
Automatic Test Systems. Requires experience analyzing design requirements to control product quality.

Structures
Structural elements, thermal protection systems, pressure vessels. Conceive, design components/systems.

Propulsion Design
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Advanced Propulsion systems
Set preliminary design criteria for solid and liquid systems.

Control Systems Engineers
Design, analysis: Nike-Zeus, Thor.

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Design & test ground support equipment. Design electrical systems.

Chemist/Chemical Engineer
Design, develop: Electrochemical, life support devices and pre-treatment techniques for waste fluids.

Chemist—Fuel Cells
Applied electrode technology catalysis, or electrochemical technology.

Mathematician
PhD. Help make new, special purpose computers/programs.

Battery Technologists
Design, fabricate, test: High energy density batteries, electrodes, separators, cases, seals, components.

Coating Withstands Searing Exhaust Heat

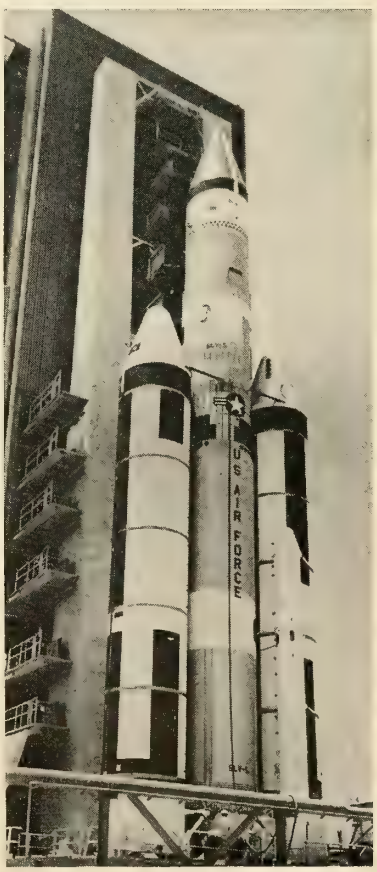
ORLANDO, FLA.—A new low-cost ceramic composite is finding initial applications in protecting launch complexes from the searing exhaust of large booster vehicles.

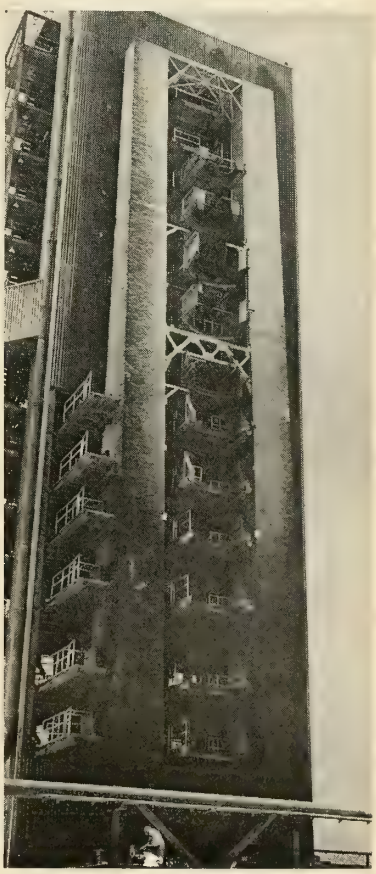
Developed by Martin Co.'s Orlando Div., the material shielded the umbilical mast, launch mount platform and the transporter cable supports at Pad 40 during the successful launch of the *Titan III-C* vehicle June 18.

Designated Martyte FS, the material withstood the 3,700°F temperatures and 650 psi pressures generated by the two 120-in.-dia. solid boosters during the launch phase. Examination of the pad showed little or negligible damage to the coating after the launch.

● **Broad application**—Martyte FS will adhere to all cementable surfaces

PAD 40 before and after initial launch of Titan III-C. Martyte FS coating was darkened by exhaust blast, but physical damage was negligible. The material has been tested in solid rocket exhausts using aluminized propellants at temperatures exceeding 5,000°F and thrust of more than 1,000 lbs. without deterioration of the substance.





without priming or supplementary adhesives. The composite is both trowelable and air placeable and can be applied in any thickness.

The material hardens in some 6 to 8 hours. It is ready for use 12 hours after application. Curing at ambient temperatures, the resultant coating is tougher than concrete and unaffected by moisture or humidity.

Martyte can be applied under water and its viscosity can be controlled to requirements ranging from free-flowing to non-sagging.

Martin-Orlando specialists have tested Martyte FS in solid rocket exhausts using aluminized propellants at gas temperatures exceeding 5,000°F and thrust of more than 1,000 lbs. Martin's Denver Div. has used the material in connection with booster engine tests. It has also protected flame deflectors during *Pershing* test launches. The composite shields the test mount in Martin-Orlando's FLAME high-temperature facility.

Mixed on the spot, Martyte FS lends itself to refurbishment applications, since it can be troweled over cracks and other defects resulting from launch pad operational use.

The composition of the material is proprietary with Martin Co. but it is known to be a ceramic-plastic composite. The material is manufactured and sold commercially by the Presstite Div. of Interchemical Corp. under license from the Martin Co.

The various properties of the composite, as determined by Martin-Orlando engineers, are as follows: (Specimens of Martyte FS, ⅜-in. thick on ¼-in. aluminum plates were undamaged by five cycles of immersion in water at 200°F followed by immersion in liquid nitrogen at —320°F.) Erosion tests show an average 4.0 mils/sec. loss with a backface temperature of 95°F.

The material has excellent erosion resistance and insulating properties and functions as an ablator at high temperature and high pressure rates. Martyte FS can also be used as a radome or for bunker protection. ■

CHARACTERISTICS OF MARTYTE

Property	Unit	Value
Tensile yield strength	psi	2460
Tensile ultimate strength	psi	2460
Tensile elongation	%	1.2
Tensile modulus	psi	270,000
Compressive yield strength	psi	12,400
Compressive ultimate strength	psi	11,400
Compressive modulus	psi	710,000
Flexural strength	psi	5260
Flexural modulus	psi	2,350,000
Dielectric strength	Volts/mil	255
Dissipation factor, 10^{10}	cps	0.005
Dielectric constant, 10^{10}	cps	3.3
Hardness	Rockwell "B"	53
Lap shear	psi	1700
Density	lb/ft^3	106
Water absorption	%	1.7

space systems

ESRO II in Early Test Phase

Hawker Siddeley Dynamics, Engins Matra are joint contractors for satellite; Scout vibration specifications questioned

LONDON—Systems design of the European Space Research Organization (ESRO) satellite dubbed *ESRO-II* has been completed and engineers are at work on critically important vibrational testing of a structural model of the 160-lb. spacecraft.

These tests are said to be going well, but engineers at Hawker Siddeley Dynamics—with Engins Matra, of France, joint contractors on the program—and experimenters whose instrument packages will fly aboard the satellite are concerned about what they feel to be unrealistically harsh vibration specifications.

ESRO-II is slated to be launched in March, 1967, on a U.S. *Scout* launch vehicle from the Western Test Range (Calif.). Considering the initial launch-phase booster vibration specifications supplied by NASA, and normal amplification of those levels throughout the vehicle during the launching, engineers here say that experimenters will have to design their electronics to withstand vibrations on the order of 55 g's at certain frequencies. This has not been greeted with much enthusiasm.

Structural engineers here believe that the vibration specifications are more severe in this case than they have been for other launches with the *Scout* vehicle, and that the satellite design may therefore be paying an undue penalty for structural support and equipment mounting.

The contract for development of the satellite was let by ESRO in December, 1964. The total cost of orbiting the craft, which greatly resembles the U.S. *Early Bird* satellite, is roughly $7 million, of which some $1.6 million is for booster costs. HSD will design and manufacture the satellite, and Engins Matra will contribute most heavily in the electronic systems area. HSD is expected to contribute about 60% of the funding, Matra 40%.

In addition to thermal- and vibration-test models, two prototypes and two flight models will be built. Fabrication of the second prototype, which will reflect final flight design, will begin at the end of this year, according to HSD engineers, and the unit will undergo final proof testing in environmental chambers by mid-1966. HSD hopes to have the first flight vehicle ready for shipment to the U.S. by the end of next year.

• **Maximum exposure**—The satellite will be launched into an orbit with a perigee of 218 miles, an apogee of 685 miles, a period of 99 minutes and a 98.22-deg inclination. This is calculated to keep it in continuous sunlight for as long as possible during its one-year intended lifetime. The satellite will carry seven experiments dealing with solar radiation measurements, and the intended inclination is such that the orbital plane will rotate from west to east at the same rate as the apparent motion of the Sun.

The satellite electronics include an Engins Matra attitude stabilization system that will be able to function exclusive of ground control, and an electrical power system involving use of 3,500 2 x 2-cm n-on-p-type solar cells

being provided by Ferranti, Ltd.

A slightly smaller Ferranti cell of the same type, which is highly regarded as a radiation-resistant device, is to be used aboard the *UK-3* satellite (M/R, June 21, p. 30).

The attitude control system, which will make extensive use of integrated circuitry, involves use of a Sun sensor to maintain the spin axis of the satellite perpendicular to the solar vector within ± 10 degs, and a magnetometer and torquing system for sensing the direction and strength of the Earth's magnetic field and stabilizing relative to it.

The satellite is required to spin in orbit at 15-40 rpm, and contains an on-board gas jet system which is activated by ground command when spin decays below the lower limit. *ESRO-II* will also carry horizon sensors to measure satellite attitude relative to the ground as a data analysis aid.

● **Payload**—The seven experiments include three contributed by the Imperial College-London: measurement of solar protons and inner Van Allen Belt protons over the range between 1-100 MeV; measurement of the percentage variation in magnetic rigidity of cosmic ray protons and alpha particles with respect to time; and a routine monitoring experiment of energetic particle flux that takes place in the cosmic ray and radiation belts.

The University of Leeds experiment will measure energy distribution of electrons greater than 20,000 MeV and protons above 300 MeV for the purpose of determining galactic magnetic field strength. The University of Leicester experiment will measure X-ray radiation in the 1-20 Ang. wavelengths, with a University of Utrecht experiment making similar measurements in the 44-60 Ang. regime.

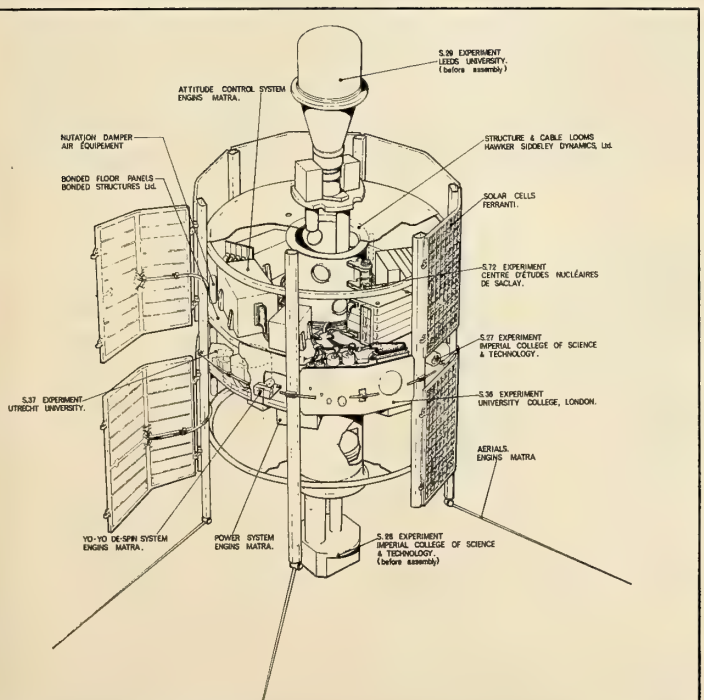
The lone French experimenter, the Centre d'Etudes Nucleaires de Saclay, will monitor the flux and energy distribution of solar and cosmic ray protons from 35-1,000 MeV and alpha particles from 140-1,200 MeV.

ESRO-II is the second of some 17 satellites the 10-nation organization has outlined in its tentative launch plans for the next eight years. Thus far, *ESRO-I* and *-II* are the only ones to move into project status.

ESRO-I, oddly enough, is scheduled for a later launch than *ESRO-II*. This arises from the fact that the latter's payload can be developed faster than that of its numerical predecessor. Like *ESRO-II*, it will be launched by NASA from the Western Test Range.

The final proof-testing of *ESRO-II* will be conducted in environmental chambers at ESTEC (European Space Technology Center), ESRO's small-scale version of NASA's Goddard Space Flight Center, which is located at Delft in the Netherlands. ■

SCHEMATIC DIAGRAM of ESRO-II satellite, scheduled to be launched in March 1967, from Western Test Range carrying solar radiation experiments.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Command Pilots' Hearts Beat Faster

NASA/AF research with X-15 and M-2 fliers indicates responsibility rather than risk causes rate to soar to 170 beats per minute or more

by Heather M. David

THE SPACE-AGE phenomenon of extremely high heart rates among pilots may reflect the degree of responsibility they have for controlling their craft rather than a response to physical danger, as had been supposed.

This conclusion was reached after an intensive NASA monitoring program in which pilots flew a number of missions in high performance aircraft.

It was *X-15* monitoring experience that first tipped off the aerospace medical community that something unusual indeed was happening. Physicians, accustomed to clinical measurements of heart rates rarely exceeding 100 beats per minute except in the very sick, were flabbergasted to find that *X-15* pilots had rates of over 170 at times during their missions.

Recently, reports Dr. James Roman in the June *Aerospace Medicine*, it was found that one M-2 pilot had a sustained heart rate of 188. The same man's rate measured in an F-104 aircraft was only 89.

Mercury and *Gemini* astronauts have had slightly lower rates, peaking at 130-140. However, *GT-4* pilot Edward White averaged 150 during his extravehicular experiment, with a peak of 178 just before re-entering the spacecraft.

Such findings led NASA to realize that it must develop a better understanding of normal reactions in research flight situations so that medical monitors can properly assess astronauts' conditions when confronted with data during an actual space-flight.

● **Surprises**—Roman reports that the conclusion that responsibility—rather than risk—may cause the high physiological readings was borne out in a special test series conducted in a broader NASA monitoring program.

In this test, in 37 flights of a two-place high-performance aircraft, the pilot in control had much higher heart rates than did the "passenger pilot." The doctors were surprised at this, since they had found that the passenger pilot, with nothing to do, felt uneasy during the more demanding or dangerous parts of the mission and wanted to be in control himself.

Strangely, while the passenger pilots did exhibit such nervousness, their heart rates were lower: the command pilot, appearing calm and confident, registered the high heart rate. In one flight, for example, the command pilot had a reading averaging 150, the passenger 90 beats per minute.

Such results cannot be extrapolated to the general population, Roman points out, since the subjects studied are in their present jobs after a long process of selection. Those who reacted strongly to physical risk or danger were dropped out earlier.

● **Comprehensive program**—The whole problem of physiological response to dynamic situations is being studied and better instrumentation being developed in a broad program being conducted jointly with the USAF Aerospace Research Pilots School at NASA's Flight Research Center at Edwards AFB, Calif. The Air Force Aerospace Medical Center also is deriving information from the project, and provides support in conducting baseline studies and aiding in evaluating some data. Other NASA centers supporting the program are Ames and Manned Spacecraft.

Permission was obtained by NASA to conduct studies using the Aerospace Pilots School students—all of them experienced jet pilots. Roman points out that the group involved is particularly suited to NASA's interests since the students are representative of an astronaut population. In fact, if the trend continues, future space crews will include many graduates of this school.

Of further advantage for research purposes is the fact that the students fly identical or nearly identical missions, in a series ranging from relatively easy to very difficult.

● **Instrumentation developments**—During the past year a number of different instrumentation techniques have been developed for the program.

One unusual requirement is that the medics have only three minutes in which to work with the pilots on their way to the flight line.

Accordingly, a routine has been set up whereby the pilots enter a special van on their way to the flight line. Here conductive paint electrodes are sprayed directly on the skin and protective spray applied over them. The leads are then attached and a tape recorder placed in the leg pocket of the flying suit.

The tape recorder-signal conditioner system, developed for the Flight Research Center by AiResearch Mfg. Div. of The Garrett Corp., allows continuous recording for one hour and 45 minutes of six physiological parameters, including voice.

Roman says other instruments being investigated at FRC's Office of Biological Research and Medical Operations include a mass spectrometer which will eventually be developed for spaceflight, oxygen consumption apparatus, parotid secretion monitors, vibrocardiogram systems and blood-pressure devices.

The mass spectrometer, which will be tested for feasibility of incorporation into a complete cabin atmosphere monitoring system, has had preliminary flight tests which indicate that it is reliable and easy to use operationally. It weighs less than 50 lbs., including vacuum system, and measures 10 x 10 x 20 in. In its present form, Roman says, a representative sensitivity figure would be 200 parts per million at one atmosphere, but the spectrometer can be modified to permit higher sensitivities.

NASA has a contract to develop a flight-rated instrumentation package, now in the breadboard stage, which will monitor oxygen consumption, carbon dioxide production, respiratory quotient and respiratory flow.

FRC is very interested in developing a flight-rated vibrocardiogram system, Roman says. In one phase of this effort, 12 dogs have been instrumented with cardiac strain gage arches to check out the correlation between heart actions and new vibrocardiogram sensor designs as they are developed. Another effort is aimed at elimination of motion artifacts, through sensor design and computer averaging techniques. ■

IEEE Lays Groundwork For Aerospace Group

by Charles D. Lafond

HOUSTON—Details of the formation of the largest technical group within the Institute of Electrical and Electronic E_gineers (IEEE) were completed here at the 1965 Aerospace Technical Conference and Exhibit.

Called the Aerospace and Electronics Systems Group, it is comprised of four former IEEE technical groups with a total membership of 10,500. As a result of the merger, effective July 1, five major annual electronic conferences will be replaced with a single meeting to be called the Aerospace and Electronic Systems Convention. The first will take the place of the previously scheduled 1966 Military Electronics Conference (MIL-E-CON) in Washington, D.C., officials said.

All future A&ES conventions will be held in the fall and will alternate between the east and west coasts. The 1967 meeting will be held in Los Angeles, the 1968 convention in Boston.

● **Strong member support**—The four merged IEEE groups cover Aerospace, Aerospace and Navigational Electronics, Military Electronics, and Space Electronics and Telemetry.

A vote by the affected 10,500 members strongly supported the move and ratification was accomplished last Feb. 1. Dr. Lester C. Van Atta of NASA's Electronics Research Center in Boston will chair a 24-member administrative committee to head the new group.

A single *Transactions* will replace the four previously published by the IEEE groups.

Eight broad technological areas will fall within the scope of the A&ES group: Systems Organization and Management, Radar and Sonar Systems, Navigational Systems, Command and Control Systems, System Integration and Support, Electrical Systems and Energy Conversion, Instrumentation and Telemetry, and System Modeling and Simulation.

● **Future meetings**—The single annual A&ES convention, which will be financially supported by industry, will include a technical exhibition. Whatever specialized symposia are required by the new IEEE group will be held without industry support.

The IEEE group will continue to cosponsor the National Telemetry Conference (NTC), the Western Electronics Show and Convention (WESCON), the National Electronics Convention (INEC), and the National Aerospace Electronics Conference (NAECON).

Conferences to be eliminated include MIL-E-CON, the Aerospace Technical Conference and Exhibit, the Winter Military Electronics Conference, the Annual Telemetry Conference, and the East Coast Conference on Aerospace Navigational Electronics (ECCANE).

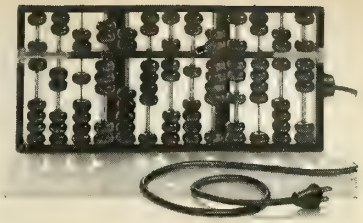
● **Attendance poor**—The need for merger and resultant reduction in number of conferences is based in part on the poor attendance by IEEE members during the past few years. The merger also represents the first attempt to eliminate group duplication resulting from the merger of the Institute of Radio Engineers and the American Institute of Electrical Engineers in 1963.

For example, at the recent Aerospace Technical Conference here, total attendance was less than 450 and there were fewer than 20 paid exhibitors in the exhibit hall. The conference will be hard pressed to break even with such a turnout, yet this occurred, said one official, in a space-oriented city having an IEEE membership exceeding 1,800.

The conference met the same end in Phoenix last year. The final meeting, called the Conference on Aerospace Systems, to be held in Seattle next year (July 11-14, 1966), may suffer even more since it is not planning to have exhibits. Officials have indicated, however, the possibility of employing demonstration systems in the lecture halls for those giving papers.

Others numbered among the meetings to be dropped have suffered equally dismal support.

Group officials cautiously predict that the single surviving conference will draw 4,000-5,000 attendees—a figure approximating the annual attendance at the MIL-E-CON in Washington. ■



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French Market Expected to be Stable

Some $50-75 million annually goes for purchase of U.S. equipment for military electronics; nation is rapidly developing capabilities

by Michael Getler

PARIS—The French Délégation Ministériele pour l'Armament (DMA), the coordinating center for French military weapons development and production, now spends "a good 10-15%" of its military electronics budget for U.S.-built or licensed equipment, according to highly authoritative sources here.

"Possibly $50-75 million is spent annually with U.S. companies," these sources report, which indicates that the percentage figure may actually be slightly higher than that stated, since the French say they now spend about $300 million per year with industry for military electronics equipment of all types.

French expenditures for military electronics are expected to increase by 8-10% annually during the current five-year plan, which will carry the expanding French military forces into 1970. The sources interviewed say the government is attempting to keep overall military expenditures within a 6-7% annual growth figure in line with the projected growth of the gross national product here.

Despite new electronics capabilities sprouting rapidly in France, the ratio of business with U.S. firms is not expected to be altered within the next few years. The reason is that while French capabilities increase, U.S. technology will also advance, and the French indicate there will be, at least for the near term, an equivalent market here for some of the highly specialized equipment they import. "We hope to keep this type of relationship with the U.S."

● **Where the money goes**—The current level of electronic spending here reflects heavy investment in telecommunications equipment, but informed sources say this will decrease shortly in favor of increased spending for radar detection systems, electronic countermeasure equipment, and data-handling systems. Also due for a proportionate increase is basic research on components and microcircuit techniques. This research is directed at closing the gap between French and U.S. technology.

Spokesmen interviewed here point out the French military electronic requirements are almost as varied as those of the U.S., the French having put large-scale missile programs, high-performance nuclear bombers, ballistic missile firing submarines, and a space vehicle launcher program into development.

The production market for the associated electronics in France, however, in terms of the numbers of units required, is still quite small in compared to that in the U.S. The result is that expensive research on new techniques has not been primed too heavily by return on production contracts.

The major imports from the U.S. are very-high-grade components for space applications, high-power transistors, intergrated circuits, and certain complete systems, such as tactical shipboard data-processing systems, where only a few units are required. The French also have imported certain large-scale scientific computers they say "are just as uneconomical to produce in France as they are in the U.S."

"We have not been developing equipments of which we only need a few unless it is obviously worthwhile technically. We can't afford to develop all aspects of military electronics, but we do have all the needs. We must also choose those areas of research that will pay off either in terms of production or technology."

However, a look into the way in which the French military electronics budget is now divided between research, development and production shows clearly that the French are determined to do the groundwork.

● **How much research?**—About 20% of the total French military electronics budget is devoted to research and development. French sources say the optimum ratio of R&D to production in the country should be much higher than 4:1, probably about 9: or 10:1.

"This doesn't mean we are spending too much on research, it means only that we are not spending enough on production. The support of this current ratio, however, is an investment which marks the willingness of France to stay in the forefront of electronics." The current proportion of R&D to production is likely to continue constant over the next several years, sources here say.

Current French electronic strengths, according to experts here, lie in such areas as millimeter-wave tubes, and longer wavelength backward-wave tubes.

Also, French developments in lasers, satellite ground tracking receivers, and sensor systems, particularly in the IR region, have moved ahead rapidly (M/R, June 28, p. 16).

The French are also about to initiate development at three firms for a series of high-grade transistors, providing 50 watts at 150 mc, 5 watts at 500 mc, and 1 watt at 1 gc. Also, production of intergrated monolithic silicon logic circuits, primarily DTL and DCTL types, will go into production shortly, according to sources here, with an output of "several tens of thousands of each type per year." Some of this will be

accomplished under U.S. licensing arrangements.

● **Advanced communications**—The French also feel strongly that the technology they have developed in the field of survivable communications in an environment of heavy destruction is possibly the most advanced in the world. They claim major advances in development of improved switching systems using PCM techniques for multi-path communications links.

The French are also fostering the use of SSB with HF communications systems in an attempt to make more efficient use of available military channels. Also, across-the-board R&D is related to use of higher frequencies, improved directivity, weight and power reductions, and bandwidth/channel increases. Also said to be under development are new microwave links operating at frequencies of 15 gc for military communcations.

Another indication of the manner in which French electronics is being strengthened is that electronics research within the DRME, the government organization in charge of research and test methods (somewhat analagous to the DDR&E in the U.S.), is likely to grow faster than other fields.

The DRME reports that research into silicon microcircuit design has doubled in the last two years, now being supported by about $2 million annually. Thin-film hybrid circuits are also under study. Research is also being supported in both ruby and neodymium-doped glass lasers, CO_2 lasers operating in the near IR, and systems using YIG (yttrium iron garnet) material.

In the solid-state area, special attention is currently given to development of low-noise amplifiers, varactor diodes, and frequency multipliers. Solar cell research is aimed at exploring use of cadmium sulfide or cadmium tellurium devices to replace silicon cells as a means to improve radiation resistivity.

What is perhaps must important to the French electronics industry about the DRME operation is that 80-90% of the funding is spent with industry and the universities. Very little research is supported by government labs. ■

space electronics

Antenna Will Withstand Nuclear Blast

Martin-Orlando has hardened microwave system to survive direct exposure to nearby multi-megaton explosions

A HARDENED microwave antenna, capable of withstanding the effects of a high-yield nuclear weapon at close range, has been developed by Martin Company's Orlando, Fla., Division under contracts with the Air Force's Rome Air Development Center. Details of the exact effects the antenna is designed to withstand are classified, but it reportedly will be capable of surviving direct exposure to multi-megaton nuclear explosions in the "high-overpressure" region.

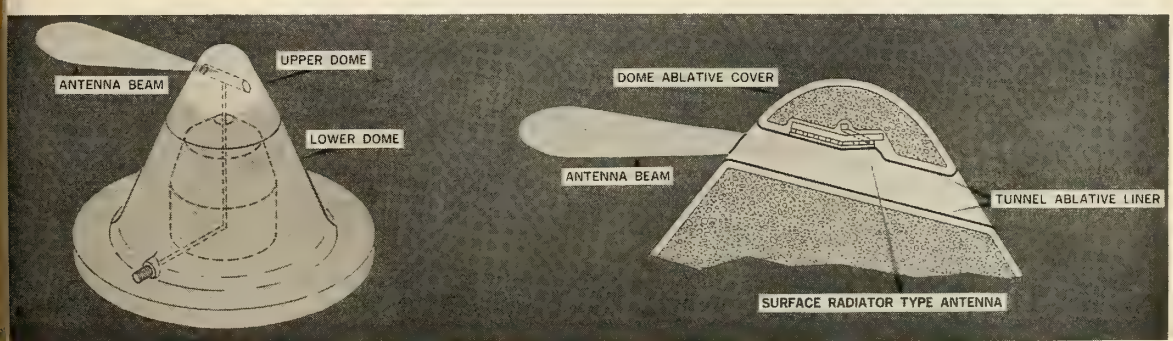
The antenna is contained in a dome-shaped reinforced concrete structure 31 ft. high, more than two-thirds of which is below ground. The radiating element is located in the ceiling of a sloping tunnel in the exposed portion of the dome. All exposed surfaces are covered with an ablative material.

The above-ground portion of the dome is shaped to minimize the effects of dynamic pressure and to obtain a low overpressure reflection factor. The slopes of the side are kept as shallow as is practical.

The depth of the below-ground portion, Martin said, was determined by the dynamic load on the exposed portion, and the diameter of the base (48 ft.) was fixed by the angle of tilt permissible for antenna performance. The base of the dome is a solid, with a cavity in the lower section suitable for housing transmission and power equipment for an integral installation if desired.

● **Debris problem**—Studies leading up to the design of the dome antenna determined that the limiting factor, as far as antenna hardening is concerned, is the debris, or throw-out associated with a nuclear blast. Antennas can be designed to survive the effects of blast, overpressure, thermal and nuclear radi-

HARDENED, CONICAL ANTENNA developed for Air Force shows tunnel configuration and location of radiation element. More than two-thirds of 31-ft.-high structure is buried. Exposed portion is covered with ablative material to protect concrete.



ation up to near ground zero, but unless some type of mechanical debris-clearing can be incorporated, effectiveness ceases as the antenna becomes covered with debris.

The Martin design is intended to overcome this limitation as much as possible without any clearing apparatus. The location of the active element, designers claim, in the top of the tunnel protects it from damage from blast-driven debris. Also, the design is such that the antenna is relatively insensitive to throw-out and debris within certain limits. Debris must be high enough to block the tunnel entrance before performance is degraded. With an exposed antenna, even a small amount of debris on the surface will seriously deteriorate performance.

The overall environment in which a hardened antenna must survive and remain operable poses some formidable design problems. The magnitude of dynamic effects, thermal flux, and nuclear radiation are far beyond the failure point of conventional antennas. In addition, ground shock effects equivalent to an earthquake, electromagnetic effects approaching a direct lightning strike, and crushing force combine to challenge designers.

An existing antenna cannot be hardened; a hardened antenna must be designed, Martin engineers assert. Conventional antennas will usually fail at an overpressure of less than 5 psi. Even with structural redesign, conventional antennas cannot be expected to withstand more than 15 psi.

• **Antenna requirements**—The antenna selected for hardened design by Martin-Orlando was a unidirectional microwave antenna with the following electrical characteristics:

—Gain of 15 db to 30 db (relative to an isotropic source).

—VSWR less than 1.25:1.

—Frequency in the 7.1 to 8.4-gc band.

—Vertical polarization.

—Non-steerable beam oriented ±5 degrees of horizon.

According to Malcolm Stephens, Martin-Orlando research engineer who designed the antenna, it would be no problem to achieve these requirements in a normal environment, but when the nuclear environment was considered, the design became difficult. Severe mechanical and physical loads are imposed on the antenna by the environment, and, at the same time, disorientation must be limited because of the antenna's electrical characteristics. The antenna will undulate from the effects of ground shock and at the same time will undergo both horizontal and vertical displacement.

The allowable tilt (or yaw) angle of the antenna is a function of its beamwidth. Because of the electrical characteristics of the antenna type selected, tilt of the dome could not be allowed to exceed three degrees. This required a base large enough to stay within this limit under the most critical conditions.

The dynamic load on the antenna exposed above the ground established the amount of structure below ground necessary to withstand this load. To keep this dynamic load within limits that could be met, it was necessary to choose a configuration that offered the lowest possible aerodynamic drag.

The overpressure level specified for the antenna indicated that it would be engulfed in the nuclear fireball. Thus the antenna would receive thermal energy first by incident radiation, then by radiation, radiation diffusion and, finally, by convection. This indicated that the antenna must survive integrated thermal fluxes on the order of 2.5×10^6 Btu/ft^2. Significant neutron and gamma radiation must be survived as must the effects of debris, both that resulting from crater throw-out and blast-driven debris.

• **Antenna elements**—A study of possible antenna configurations indicated that end-fire surface wave antennas most nearly met the environment-imposed requirements. This type of antenna is also readily adaptable to installation in the roof of the tunnel.

Two alternate antenna configurations were selected for use in the tunnel dome structure, both being of the end-fire surface wave type: a corrugated surface wave antenna fed by a five-element parasitic slot array, and a 22-element parasitic slot array. These two antennas met all the electrical requirements. An operating frequency of 7.8 gc—in the middle of the 7.1-8.4 gc band—was chosen for both antennas.

The corrugated surface of the first type is 3.75 in. wide and approximately 21.5 in. long, with a ground plane along the side and at the launching end. At its midpoint, the corrugated surface is curved enough to prevent thermal radiation outside the tunnel from being incident on the slot array feed. The total curvature of the surface is 16 degrees.

The slot-array feed is made with slot dimensions of 0.9 x 0.3 in. (I.D.), with shorts placed at proper depths to obtain end-fire radiation with a 0.5-in. slot spacing. The feed waveguide slot is also 0.9 x 0.3 in. This antenna has a vertical beamwidth of 10 degrees, horizontal beamwidth of 12 degrees, and 19 db gain. Beam orientation is 9 degrees with respect to the ground plane. Other feeds for this antenna were investigated and a flared sectoral horn selected as a suitable alternate.

The 22-element slot array antenna has slots of the same dimensions as the feed for the corrugated antenna. All slot elements are machined from a single plate so that the slot radiator and the shorted waveguides are an integral part of the plate that serves as a portion of the ground plane. The ground plane length at the launching end of this array determines to some extent antenna gain, beamwidth, side-lobe level and beam orientation with respect to the ground plane surface.

This antenna, with a 15-in. ground plane, has a vertical beamwidth of 12 degrees, horizontal beamwidth of 24 degrees, and 18 db gain. Beam orientation is 10 degrees with respect to the ground plane. A waveguide feed is used for both antennas, with a waveguide iris used to obtain the required VSWR. The waveguide is protected throughout the dome run to withstand the effects of ground shock and vibration.

The antenna elements are fabricated from a highly refractory metal to meet requirements for high-temperature capability, low electrical resistivity, and a high degree of resistance to erosion. The waveguide feed was sealed to prevent entrance of high-temperature and high-pressure gases as well as small particles of debris. The material used had to have high strength at elevated temperatures and a low loss tangent.

• **Materials selection**—One of the most severe problems in hardening involves the selection of suitable materials. Concurrent with the antenna hardening study, a hardening materials program was conducted, also under the sponsorship of Rome Air Development Center.

Several kinds of concretes were tested during the development and it was found that under the anticipated high thermal flux conditions, loss of surface concrete would be so severe that antenna operation and survivability would be seriously impaired. Consequently, a thermal shield for the dome was necessary and exposed areas were covered with an ablative material, self-bonded to the treated surface of the concrete.

The ablator is pigmented with a highly reflective material, and the surface of the thermal shield ground to a smooth surface and then coated to prevent moisture absorption and to increase reflectance.

• **Configuration advantages**—The dome shape selected for the antenna has a number of distinct advantages. The shape is such that minimum forces are received by the structure.

Stresses produced by four different types of loading were investigated during the development: uniform external pressure, wind pressure, vertical accelerating force applied to the base, and horizontal accelerating force applied to base. The results of this study indicated the conoidal dome shape was optimum. Configuration and dimensions

also provided for the minimum amount of antenna disorientation, well within the maximum allowable tilt of three degrees.

Installing the antenna in the tunnel in an inverted position also offered several advantages. Probably the most significant is the ability to survive the thermal flux associated with a thermonuclear explosion. The geometry of the tunnel and the low incident angle of thermal radiation on the radiating element indicates a reduction of thermal energy seen by the antenna by a factor of almost a hundred compared to an antenna in free air. This one factor alone could mean the difference between successful operation or failure of an installation.

The curved antenna configuration offers significant advantages, since it allows the active antenna element to be in the shadow from direct thermal radiation and also does not subject it to damage from blast-driven debris. The inverted position of the antenna in the tunnel is also advantageous from the standpoint of withstanding normal climatic conditions. Snow, ice, dust, or rain will not degrade performance.

● **Antenna performance**—A number of full-scale electrical models were built during the course of the program and tested to determine performance and characteristics under hardening provisions. Radiation patterns were taken in an RF darkroom using conventional polar pattern recording.

The corrugated surface-wave antenna showed good patterns in both elevation and azimuth with the azimuth pattern being exceptionally clean. The patterns for the slot array, as with the corrugated surface-wave antenna, proved very good. All tests were conducted in free air.

Patterns taken of the antenna in the tunnel showed generally that side lobes were reduced and patterns cleaner with the antenna in the tunnel rather than in free air. ■

space electronics

Early Bird Speeds Chart Transmission

Tiros IX weather maps of fine quality sent to France and returned using facsimile equipment built by Alden Electronic in-house

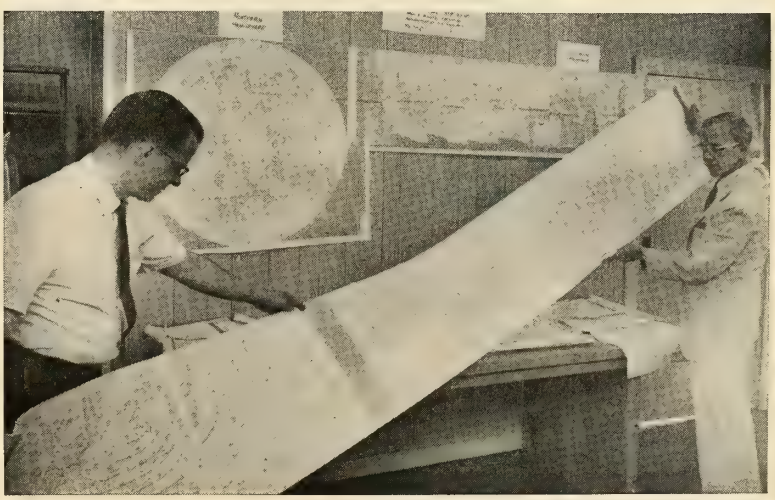
INTERNATIONAL transmission of weather charts at speeds up to 16 times faster than present communications networks has been demonstrated using the *Early Bird* communications satellite and high-speed facsimile techniques.

Using equipment developed by Alden Electronic & Impulse Recording Equipment Co., Inc., Westboro, Mass., data gathered by the *Tiros IX* weather satellite was successfully sent from the Washington World Meteorological Center to the French National Meteorological Service. For demonstration purposes, the weather charts were then looped back to the U.S. Facsimile charts received on both continents were considered of excellent quality.

The transatlantic weather data exchange was conducted last month for the U.S. Weather Bureau by the Communications Satellite Corp., Alden Electronic, Press Wireless, Inc., and the French Post and Telegraphs Corp. In addition to successfully demonstrating a possible expansion of communications resources needed to implement the World Weather Watch, the exchange of graphic communications was considered another means of greater cooperation in government, commerce and industry between the U.S. and Europe.

Operating on a 48-kc bandwidth in the first public demonstration of *Early Bird's* broadband capabilities, the Alden-developed flat copy scanner transmitted charts of the current 3-hour weather pattern to France in two minutes. The charts were derived from two orbital passes of *Tiros IX* over western Europe and the eastern Atlantic. A continuous 10-ft. mosaic of cloud-cover charts of the northern and southern hemispheres provided, in less than 10 minutes, the

OFFICIALS at Alden Electronic examine facsimile maps transmitted from Paris to White Plains, N.Y., and back to Paris via Early Bird satellite.



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Ten editors, under the direction of Bill Coughlin, VP and Editorial Director of AMERICAN AVIATION PUBLICATIONS, and Bill Hall, Editor of MISSILE/SPACE DAILY will be at the Show reporting all important developments.

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During the four days of the show, MISSILE/SPACE DAILY will provide exhibitors and non-exhibitors an outstanding opportunity to sell their products and capabilities with low-cost advertising.

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MISSILE/SPACE DAILY will publish a tabloid size newspaper during the four days of the AIAA Show. It is the only official newspaper of the show.

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Advertisers using the July 19, 1965 Pre-Show Issue of MISSILES AND ROCKETS earn a 25% discount on advertising appearing in the daily newspaper.

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ADVERTISING CLOSES: JULY 6, 1965

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tropical latitude of the global weather pattern collected by *Tiros IX* for a 24-hour period.

Also transmitted were two kinds of computer-plotted charts showing upper-air analyses from the surface to 10 millibars. For this analysis, the Weather Bureau used both a current operational model and a new experimental model that contains effects of the air-sea interface. By sending both types of charts, the French were able to compare the two computer prediction programs.

● **High-resolution data**—The maps were transmited to Paris with a resolution of 96 lines per inch and at a speed of one map per minute. Weather data of the detail of that carried by *Early Bird* would ordinarily have required eight separate cables and receivers and taken eight times as long. French officials described the clarity of the copy received from *Early Bird* as indistinguishable from local copy sent to a recorder within Paris headquarters.

The satellite's capabilities were then turned over to French communications experts for transmission of French weather data to White Plains, N.Y., at a speed of 960 rpm and resolution of 48 lines per inch. This effectively doubled the U.S. rate and cut transmission time to one map every 30 seconds. The material was looped back to Paris and was received, nearly 90,000 miles later "with no degradation whatsoever," officials said.

In addition, the French scanned one of the first high-speed transmissions received from the U.S. and sent it via radio transmitters to the meteorological community of Europe at 120 rpm and 96 lines per inch.

● **First international use**—The facsimile equipment was developed in-house by Alden about two years ago, but last month's demonstration was its first application for international communications. The hardware has been used by the Weather Bureau to connect its stations within the U.S. and by NASA for graphic data exchanges among its field centers. Use of the equipment costs the Weather Bureau an estimated 5¢ per 9 x 10-in. map per station.

The demonstration also included a display of Alden's facsimile chart coding and selection equipment for weather transmission. This involves coding every transmission and later selecting the desired maps at a recording center. This approach would permit local use of high-speed weather data by selecting only those transmissions vital to a local weather mission. ■

space electronics

products and processes

New Product of the Week:
Range Unit

A radar/laser range unit, the Model 5420, is being marketed by Eldorado Electronics. The device is a complete operational time interval counter that automatically measures and indicates distance based on the radar meter (6.676 nanoseconds.).

The solid-state unit features a meter accuracy of ±0.65 and a 1-meter quantizing resolution with no ±1 count error. It offers adjustable range gate, multiple target selection and an operating range of 1 to 100,000 meters.

Other specifications include a sensitivity of 0.5v minimum; amplitude of 0.5 to 12v; negative polarity; pulse width of 20 nanoseconds minimum; and overload of 20v. Input impedance is 50 ohms nominal.

Three reset modes are incorporated: manual, automatic and remote. Remote reset requires a 6-v negative pulse with a minimum duration of 2 microseconds. Standard operating temperature range is 0° to 50°C. The device can be packaged for airborne requirements to meet MIL–E–5400 or MIL–E–16400 specifications.

Circle No. 151 on Subscriber Service Card

Crystal Oscillators

A line of voltage-controlled crystal oscillators, in any specified center frequency from 10 to 20 mc on short lead time, is being marketed by Damon Engineering, Inc.

The Series 5658WB units are solid-state quartz crystal stable oscillators whose frequencies can be varied linearly by an external d-c or a-c modulating signal. Specified center frequency is externally adjustable by ±1 kc.

Other specifications include a frequency deviation of ±20 kc; sensitivity of 10 kc/volt minimum; linearity of ±1% from the best straight line. Modulation rate is dc to 5 kc, ±1 db. Stability versus temperature is ±0.005%, —10° to 50°C.

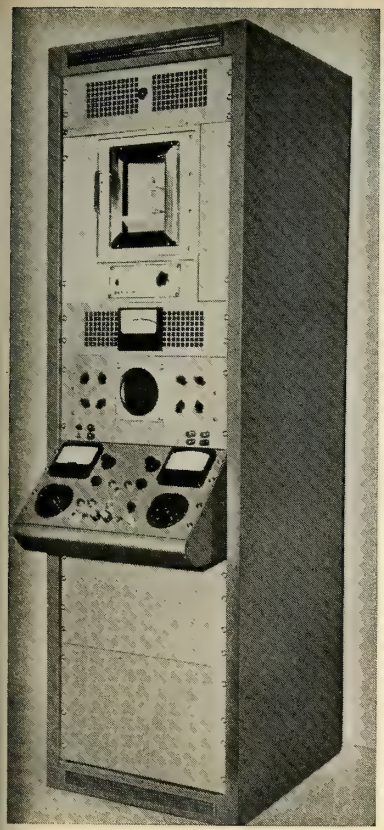
Circle No. 152 on Subscriber Service Card

Actuator

General Precision, Inc.'s Link Group has developed an actuator that provides a combination shock/pressure output, initiating a fluid reservoir valve.

The Model AC-171 is hermetically sealed with a 9/16-18 thread at the output end. Characteristics include an all-fire current of 5 amps and a no-fire current of 2 amps. Operating temperature range is —65° to 350°F. Auto-ignition temperature is 500°F.

Circle No. 153 on Subscriber Service Card



Rectifier Test Set

A silicon rectifier test set that extends the switching concept to the high-voltage region has been developed by Instrument Research Co.

The Model K-1 operates to a maximum inverse voltage of 20 KVP and a maximum forward current of 6 amps peak. The device features an oven test chamber that permits rectifier testing to be done in a controlled ambient to 150°C. The unit can simulate actual conditions of PIV, forward current and ambient temperature, the firm points out. For a full load peak power of over 120 kw, it draws less than 300 watts line power.

Circle No. 154 on Subscriber Service Card

Exciter-Amplifier

United Control Corp. is marketing an exciter-amplifier and two pressure transducers for aerospace, oceanography and industrial applications.

The transducers, Models 8140 and 8150, directly convert pressure to output frequency through a vibrating wire. Output is a frequency-modulated signal inversely proportional to pressure, eliminating the need for a voltage-controlled oscillator. Standard pressure ranges are 0-25 to 0-1,000 psia and 0-1,000 to 0-10,000 psia. Input power for both transducers is 12v dc, 5 ma, or 28v dc, 8 ma.

The Model 810 amplifier has an output amplitude of 1.5 ±0.25v RMS at 70°F. Output impedance is 5 k ohms maximum; minimum load impedance is 6 k ohms. The unit can withstand vibrations of 40 g's, 20 to 2,000 cps; acceleration of 100 g's; shock of 100 g's, 10-millisecond duration; and temperatures of—65° to 200°F.

Circle No. 155 on Subscriber Service Card

Digital Signal Simulator

Telemetrics, Inc., is marketing a digital signal simulator that can provide a continuously adjustable bit rate from 10 to 80,000 bits/second.

The Model 504's basic bit rate of the output serial code can be derived from an internal oscillator or an external source. Word length is selectable from 2 to 16 bits; odd or even parity may be inserted at the end of each word, or locked out. The variable main frame length (2 to 128 words) allows four separate words to be generated in one main frame: common word, special word A, special word B and special word C. Special words may be inserted at any frame location.

Circle No. 156 on Subscriber Service Card

Frequency Source

Sanders Associates, Inc., is marketing a miniature solid-state microwave frequency source, the Model DG 512.

The unit delivers greater than 20 milliwatts output power over most of the operating temperature range of —55° to 125°C. Input power is 20v at 8 ma. Typical frequency stability is 10 parts/million/°C between —25° and 100°C and 58.4 parts/million/°C over the full operating range. Output impedance is 50 ohms nominal.

The device measures 3.1 cu. in. and weighs 4.5 oz.

Circle No. 157 on Subscriber Service Card

EBW Squib

An explosive bridgewire squib with a safety spark gap has been developed by Litton Industries, Inc.'s Electron Tube Div.

The Model 398 is said to be unaffected by wide temperature cycles, high humidity and long shelf storage. Each device is "baked out" at more than 500°F to eliminate contaminants. The spark gap has been 100% "aged" and tested to break down within consistently narrow limits to ensure correct fire-no-fire characteristics, the firm says.

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The Applied Physics Laboratory, The Johns Hopkins University, has several immediate openings for qualified engineers and physicists to participate in pre- and post-patrol evaluation of the Polaris weapon system. Working in close association with Naval operational personnel, APL staff members develop test objectives, establish test procedures, and monitor tests at Cape Kennedy and aboard submarines. Particular emphasis is placed on the analysis of test data and the development of recommendations for improvements in system and sub-system performance. New staff members are normally assigned to a sub-system area, such as Missile, Fire Control, Navigation, or Launcher, with later opportunities for broader system assignments based on experience and knowledge. A degree in physics or electronic engineering and experience in one of the above areas are preferred.

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MILITARY PUBLICATIONS

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ARMED FORCES MANAGEMENT*	**222**	**151**	**+47.0%**
Data	74	55	+34.5
Army	147	118	+24.6
Signal	143	129	+10.9
Ordnance	90	85	+ 5.9
USNIP	137	133	+ 3.0
Journal	137	155	−11.6
Air Force	198	263	−24.7
	1148	1089	+ 5.4%

AEROSPACE PUBLICATIONS

	1st 5 Mos. 1965	1st 5 Mos. 1964	Percent Change
MISSILES AND ROCKETS*	**454**	**439**	**+ 3.4%**
Aviation Week & Space Technology	1257	1275	− 1.4
Space Aeronautics	383	523	−26.8
	2094	2237	− 6.4%

AVIATION PUBLICATIONS

	1st 5 Mos. 1965	1st 5 Mos. 1964	Percent Change
AMERICAN AVIATION*	**264**	**222**	**+18.9%**
Flying	286	242	+18.2
B/CA	280	241	+16.2
Flight	187	187	——
AOPA	262	271	− 3.3
	1279	1163	+10.0%

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Mergers and Acquisitions

Raytheon Co. is continuing its acquiring ways with the announcement that it is planning to absorb Macalaster Scientific Corp. of Watertown, Mass., the third acquisition for Raytheon within a month, and the eighth within 14 months (M/R, May 10, p. 35; June 7, p. 47). The last three acquisitions—Macalaster, Dage-Bell Corp., and Edex Corp.—have been active in the field of educational devices. The Dage-Bell deal was overwhelmingly approved by D-B stockholders on June 14 by a vote of 337,612 for and 3,075 against.

New Activities

General Motors Corp. has elevated the AC Spark Plug Div.'s Electronics Div. to corporate division status. The Milwaukee operation will be known as the AC Electronics Div. The management of the new division will report directly to the group vice president of GM's Accessory divisions. The move is viewed as an expression of confidence in GM's defense and space electronics activities. . . . *Atlas Chemical Industries, Inc.'s Aerospace Components Div., Wilmington, Del., has entered into a pact with Ordnance Associates, Inc., of Rialto, Calif., whereby Atlas will make and market OA products, including actuators, cartridges, detonators, drogue guns, miniature cutters, firing mechanisms, gas generators, igniters, squibs and switches. Atlas will manufacture the new products at Valley Forge and Tamaqua, Pa.* . . . Lear Siegler, Inc., Santa Monica, Calif., has formed Information Systems Co. to enter the field of computer-based information systems for commercial and military use. Information Systems will operate independently of LSI's present 12 divisions.

Facility Expansions

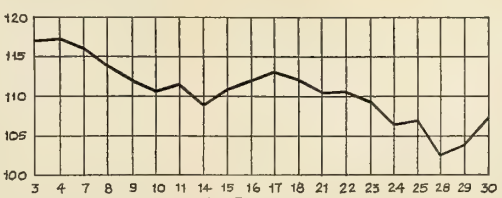
Lockheed Aircraft Corp. is building an old-and-new records center at its Rye Canyon Research Laboratory near Saugus, Calif. The $500,000 building is designed to withstand natural and man-made disasters and to serve as a company "safe deposit box". More than 200 designs for transportation vehicles spanning the range from propeller-driven aircraft to space craft will be stored in the center. . . . *The Solar Div. of International Harvester Co. has announced plans to open a military turbomachinery sales office in Dallas to serve the southwestern U.S.* . . . Glenair, Inc., Glendale, Calif., manufacturer of cable connector accessories and special connector assemblies for aerospace and general industrial use, has expanded its facilities by 11,000 sq. ft., bringing the company's total plant area to 26,000 sq. ft. The new area will accommodate equipment designed to raise production volume and a new board of directors conference room. Office space will also be included. . . . *Operations Research, Inc., Silver Spring, Md., has opened new offices in Cambridge, Mass., to provide improved liaison with consultants at Harvard and Massachusetts Institute of Technology and to expand ORI's capability to work with NASA's Electronics Research Center in Cambridge. ORI also plans to use the facility to carry out increased activities in urban planning and development in the Boston area.* . . . Nexus Research Laboratory, Inc., Canton, Mass., has expanded its facilities by 17,000 sq. ft., making possible increased manufacturing and research. Nexus makes operational ampliers and analog components.

International

Varec/Dynel, a subsidiary of Microdot, Inc., has joined with Wm. Neill & Son, Ltd., to form a new company in England. The new firm, to be known as Neill-Varec, Ltd., will make telemetry equipment for the foreign market. Neill & Son has also acquired a minority interest in S.A. Microdot-Varec, N.V., Microdot's manufacturing subsidiary in Belgium. . . . *Scientific Data Systems, Santa Monica, Calif., has signed long-term agreements with Compagnie Pour L'Informatique et Les Techniques Electroniques de Control, Paris, and General Electric Co., Ltd., Wembley, England, granting manufacturing and marketing rights to all SDS computers and related equipment. Both of the firms will begin production of the SDS 92, 930 and 9300 computers in the near future. Terms of the agreement include payment to SDS for all SDS equipment manufactured overseas and reciprocal provisions that would enable SDS to manufacture and distribute GEC and CITEC equipment in the U.S., Canada and the Far East.*

Missile/Space Stock Index

The Missile/Space Weighted Stock Index continued to follow the pattern set by the general market, sliding badly last week and hitting a new low Monday. Monday's figure of 102.32 was the lowest since the first few days of 1965. The afternoon upturn Tuesday, which brought it to 103.51, was followed by a substantial rise Wednesday, when it closed at 107.35. This was apparently due in part to statements by Commerce Secretary John T. Connor that the "economy is fine and the future looks better."



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missiles and rockets
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contracts

AIR FORCE

$13,468,725—**Hughes Aircraft Co.,** Culver City, Calif., for modifications of missiles and spare parts.

$10,500,000—**United Technology Center,** Sunnyvale, Calif., for solid propellant motors.

$5,998,960—**Kollsman Instrument Corp.,** Elmhurst, N.Y., for spare parts for mapping and survey systems.

$4,195,000—**Collins Radio Co.,** Dallas, for antenna systems.

$3,263,602—**United Aircraft Corp.,** Norwalk, Conn., for spare parts for radar sets.

$3,195,000—**Thiokol Chemical Corp.,** Brigham City, Utah, for development of rocket motors.

$3,000,000—**Hughes Aircraft Co.,** Culver City, Calif., for *Falcon* missile adapter kits.

$2,060,755—**Avco Corp.,** Wilmington, Mass., for research and development of re-entry vehicle.

$1,800,000—**Bunker-Ramo Corp.,** Defense Systems Div., Canoga Park, Calif., for development of a computer-driven display system to be used in retrieval and analysis of intelligence information.

$1,482,734—**Dalmo Victor Co.,** Belmont, Calif., for chemical warfare detectors.

$1,446,400—**General Dynamics Corp.,** Rochester, N.Y., for communications equipment.

$1,039,437—**Aerojet-General Corp.,** Liquid Rocket Plant, Sacramento, Calif., for exploratory development to establish high-pressure chamber combustion technology with advanced storable propellants.

$945,310—**Weinschel Engineering Co., Inc.,** Gaithersburg, Md., for purchase of precision power measuring equipment.

$700,000—**North American Aviation, Inc.,** Los Angeles, for liquid rocket system conjugate structure and tankage.

$587,392—**International Telephone and Telegraph Corp.,** Gilfillan, Inc., Los Angeles, to improve operational capabilities of the mobile RAPCON air traffic control radar facilities.

$499,437—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for beryllium erosion and corrosion investigation for solid propellant rocket motors.

$412,700—**Arde-Portland, Inc.,** Paramus, N.J., for investigation and feasibility demonstration of a variable area throat nozzle system.

$377,976—**Allis-Chalmers,** Milwaukee, for 10 self-contained fuel cell modules designed for use on unmanned space vehicles.

$350,000—**Marquardt Corp.,** Van Nuys, Calif., to demonstrate advantages of free standing pyrolytic graphite thrust chambers for high-energy upper stages and attitude control.

$292,000—**Laboratory For Electronics, Inc.,** LFE Electronics Div., Boston, for the development of manufacturing processes and techniques applicable to the fabrication of random access, large-capacity mass memories.

$250,000—**URS Corp.,** Burlingame, Calif., to assist in studying the effects of accidental explosion of liquid propellants during launch or static test of missile or space vehicles.

$202,580—**TRW Inc.,** Structures Div., Cleveland, for material investigation and design concepts for non-regenerative thrust chambers with improved capabilities.

$149,955—**Stanford Research Institute,** Menlo Park, Calif., for study of behavior of high-energy inorganic oxidizers in solution.

$88,105—**Spectra-Physics, Inc.,** Mountain View, Calif., for research and development directed toward the study of rocket aspect instrumentation, calibration and data processing.

$85,000—**Information International, Inc.,** Cambridge, Mass., for extending the capacity of the newest Information International film reader recently purchased by Holloman AFB Missile Development Center, N.M.

$49,960—**Laboratory For Electronics, Inc.,** Boston, for extending multi-idler parametric technique to low-noise down-conversion with useful power gain.

$41,000—**General Electric Co.,** West Lynn, Mass., for test of *Gemini* fuel cell section.

ARMY

$17,865,016—**Raytheon Co.,** Lexington, Mass., for work on *Hawk* missile system.

$4,500,000—**Texas Instruments Inc.,** Dallas, for classified electronic equipment.

$4,229,666—**Collins Radio Corp.,** Dallas, to provide an operational intercom for NASA's Merritt Island Moon launch complex.

$2,102,733—**Raytheon Co.,** Lexington, Mass., for work on *Hawk* missile system.

$1,778,907—**Highway Products, Inc.,** Kent, Ohio, for guided missile launchers.

$1,310,346—**Chrysler Corp.,** Warren, Mich., and Pacific Missile Range, for refurbishing and checking out *Redstone* missiles and related ground equipment.

$1,102,226—**Hughes Aircraft Co.,** Culver City, Calif., for continuation of *TOW* missile system research and development.

$347,306—**Raytheon Co.,** Andover, Mass., for replenishment repair parts for *Hawk* missile system.

$272,800—**Raytheon Co.,** Andover, Mass., for reconditioning of assemblies, sub-assemblies and components for *Hawk*.

$205,489—**Louis A. Roser Co.,** Salt Lake City, Utah, for modifications to existing facilities, rocket motor surveillance facilities, Hill Air Force Range, Utah.

$200,627—**Raytheon Co.,** Andover, Mass., for repair parts for *Hawk* system.

$126,750—**Brown Engineering Co.,** Huntsville, Ala., for 12-month research for an ECM vulnerability study of the improved *Nike-Hercules* missile system.

$116,541—**Demar Construction Co.,** El Paso, Tex., for *Firebee/Towbee* launch complex, Ft. Bliss, Tex.

$96,850—**Rohm and Haas Co.,** Philadelphia, for a liquid propellant development program.

$93,869—**Radio Corp. of America,** Astro-Electronics Div., Princeton, N.J., definitizing preliminary letter contract for three months research to provide a survey of existing meteorological satellites.

NAVY

$17,521,000—**Raytheon Co.,** Lexington, Mass., for continued production of *Sparrow III* air-to-air missiles.

$6,215,980—**Aerojet-General Corp.,** Sacramento, Calif., for missile programs.

$3,900,000—**Westinghouse Electric Corp.,** Pittsburgh, for components of nuclear-powered ships.

$2,802,805—**General Dynamics Corp.,** Pomona, Calif., for work on missiles.

$2,769,100—**Hughes Aircraft Co.,** Culver City, Calif., for work on *Phoenix* missile system.

$2,042,299—**New Mexico State University,** University Park, N.M., for services and materials to operate and maintain world-wide missile range doppler tracking systems and instrumentation facilities.

$2,037,750—**Muncie Tear Co.,** Muncie, Ind., for rocket equipment.

$1,869,739—**General Electric Co.,** Schenectady, N.Y., for reactor plants for nuclear ships.

$1,250,000—**Western Electric Co.,** New York City, for oceanographic equipment.

$1,100,800—**Western Electric Co.,** New York City, for rehabilitation of Pacific Missile Range test communication cable plants at Point Mugu, Calif., and San Nicolas Island.

$1,090,660—**Radio Engineering Laboratories, Inc.,** Long Island City, N.Y., for computer command equipment.

$1,013,400—**Sparton Corp.,** Jackson, Mich. for sonobuoys.

$204,205—**Raytheon Co.,** Missile Systems Div., Oxnard, Calif., to perform flight test program for *Sparrow III.*

$149,849—**Thiokol Chemical Corp.,** Reaction Motors Div., Denville, N.J., for research and development on integral radially distributed annular combustor for prepackaged liquid rocket engines.

$99,956—**North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., to assist in preparation of design data for integrated control system for *Sea Hawk.*

$59,436—**Honeywell Inc.,** Minneapolis, Minn., for a feasibility study of the direct applicability of fluid state science to primary flight control of aerospace vehicles.

NASA

$2,206,731—**Hayes International Corp.,** Birmingham, Ala., for engineering, operation and fabrication services in support of Marshall Space Flight Center Manufacturing Engineering Laboratory.

$1,700,000—**Electronic Associates, Inc.,** West Long Branch, N.J., for purchase of large hybrid computing system to be used to simulate docking maneuvers for Project *Apollo.*

$496,679—**Hayes International Corp.,** Birmingham, Ala., for launch operation services and fabrication.

$350,000—**Martin Co.,** Baltimore, for development of the conceptual design of a micrometeoroid detection satellite that could explore the interplanetary regions of deep space.

$308,562—**Hayes International Corp.,** Birmingham, Ala., for *Saturn* booster components.

$279,381—**Hayes International Corp.,** Birmingham, Ala., for launch operation services and fabrication.

$250,000—**Marquardt Corp.,** Van Nuys, Calif., for the investigation of composite cycle propulsion systems for advanced launch vehicles.

$194,140—**Itek Corp.,** Vidya Div., Palo Alto, Calif., for analysis of coupled chemically reacting boundary layer and charring ablator.

$177,556—**Westinghouse Electric Corp.,** Astronuclear Laboratory, Pittsburgh, for light weight, versatile, non-vacuum electron beam welding unit.

$142,000—**Atlantic Research Corp.,** Alexandria, Va., for study of propellant valve leakage in a vacuum.

$139,042—**Hayes International Corp.,** Birmingham, Ala., for fabrication of *Saturn* components at Huntsville.

$129,997—**United Aircraft Corp.,** Pratt & Whitney Div., East Hartford, Conn., for exploratory investigation of the vapor chamber fin concept for space radiators.

$123,498—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., for 14-month study of advanced analytical techniques to describe the physical and chemical phenomena occurring when a manned spacecraft re-enters the Earth's atmosphere.

$98,226—**North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., for research program on radio astronomy and plasma for *Apollo* Extension System lunar surface missions.

$97,000—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., to analyze the dynamic behavior of an Earth-orbiting satellite with very large antennas.

$95,100—**Houston Research Institution, Inc.,** Houston, for evaluation of the kinetic and chemical reactions that occur in the degradation of the *Apollo* heat shield.

$95,000—**John B. Pierce Foundation of Connecticut,** New Haven, Conn., for study of heat exchange between man and environment in Project *Apollo.*

$86,155—**Westinghouse Electric Corp.,** Huntsville, Ala., for development and design of a solid-state image converter for space vehicles.

$78,000—**Ampex Corp.,** Redwood City, Calif., for one-year study on foil bearing rotor supports.

$67,845—**Trans-Data, Inc.,** Huntsville, Ala., for design, development, fabrication and delivery of a tracking data plotting and printout system.

$67,003—**North American Aviation, Inc.,** Canoga Park, Calif., for development of a super-conductive, inductance-type, high-energy density storage system.

$48,920—**Bryson Construction Co., Inc.,** Decatur, Ala., for high pressure chemical reaction test cell.

INDUSTRY

$3,000,000—**Hitco,** Gardena, Calif., from **Textron, Inc.,** Bell Aerosystems Co., Buffalo, N.Y., to provide ablative thrust chambers for the LEM ascent engine.

$2,700,000—**MEVA Corp.,** Fullerton, Calif., from **General Telephone and Electronics Corp.,** Sylvania Electric Products, Inc., Waltham, Mass., to install approximately 116 mi. of cable for underground antennas to provide backup communications between 165 *Minuteman* missile sites in North Dakota.

$1,500,000—**Beech Aircraft Corp.,** Wichita, Kan., from **Grumman Aircraft Engineering Co.,** Bethpage, N.Y., to build aerospace ground support equipment for the LEM.

$1,166,375—**Textron, Inc.,** Bell Aerosystems Co., Buffalo, N.Y., from **Douglas Aircraft Co., Inc.,** Santa Monica, Calif., for propellant tanks for the auxiliary propulsion system of the *Saturn* S-IVB.

$1,000,000—**Varian Associates,** Palo Alto, Calif., from **Raytheon Co.,** Lexington, Mass., for a very high power microwave tube for use in *Nike-X* system missile site radar.

$500,000—**Radio Corp. of America,** Aerospace Systems Div., Burlington, Mass., from **McDonnell Aircraft Corp.,** St. Louis, for the AN/APN-155 low-level altimeter.

$500,000—**Talley Industries, Inc.,** Mesa, Ariz., from **The Boeing Co.,** Seattle, for actuators to be used in the *Minuteman* ICBM program.

$400,000—**Electronic Specialty Co.,** Los Angeles, from **Texas Instruments, Inc.,** Dallas, for microwave components.

$275,899—**Hayes International Corp.,** Birmingham, Ala., from **Chrysler Corp.,** Detroit, for fabrication of *Saturn* engine shroud and skirt assembly.

$258,050—**Hayes International Corp.,** Birmingham, Ala., from **The Boeing Co.,** Seattle, for *Saturn* S-1C ground support hardware and support services.

$135,000—**C. G. Hokanson Co., Inc.,** Los Angeles, from **The Boeing Co.,** Seattle, in connection with the *Minuteman* ICBM progrem.

Whittaker Corp., Los Angeles, from **United Aircraft Corp.,** Hamilton Standard Div., Windsor Locks, Conn., for pumping system for *Apollo* space suit (amount not disclosed).

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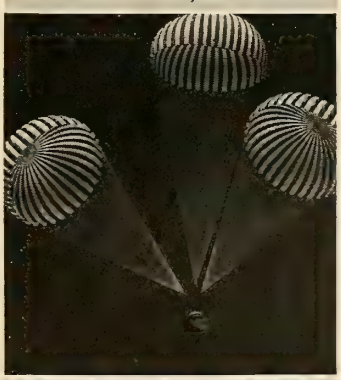

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William M. O'Hern: Promoted to corporate director of public relations and advertising at Lear Siegler, Inc. He will be responsible for the company's public relations and advertising activities in the 12 divisions in the U.S. and foreign subsidiaries in West Germany, Holland, Spain and Italy.

William J. LaHiff: Appointed vice president of administration at Kahn Research Laboratories, Inc. He was formerly a consultant to the Westrex Div. of Litton Industries.

Robert A. Burgin: Named to the newly created position of vice president and assistant to the chairman of the board of TRW, Inc.

Franklin E. Papin: Appointed manager of the applied mathematics laboratory at Melpar, Inc. Also named to a new position at Melpar was **Howland E. Gary** as manager of the simulation laboratory.

Millard West: Elected to the board of directors of Operations Research, Inc. He is also a governor of the Association of Stock Exchange Firms.

Dr. Werner R. Rambauske: Elected a vice president and technical director of Spacerays, Inc. He was formerly professor of physics at the University of Dayton.

William C. Athas: Appointed to the Advanced Development Staff/Electronics at Grumman Aircraft Engineering Corp. He was formerly chief of electronic research at the Air Force Office of Scientific Research. He will plan and program new advanced systems projects in ASW, oceanography, command and control, as well as aircraft and space systems programs already in existence.

Wayne A. Kirklin: Granted the Award of Merit by the American Society for Testing and Materials. He is manager of the Analytical Div. of Hercules Powder Co.'s Research Center.

W. Stanton Halverson, Jr.: Elected president and chief operating officer of the National Aeronautical Corp.

Charles E. Brown: Elected to the board of directors of General Laboratory Associates, Inc. He is a vice president and secretary of Glore Forgan, Wm. R. Staats, Inc.

Allan F. Hardy, Jr.: Elected executive vice president and a director of National Research Corp., a subsidiary of Norton Co.

William P. Densmore: Appointed general manager of Norton Co.'s refractories division. He is director of engineering and construction services. He was also elected a vice president of the firm on June 24.

Harold L. Latin: Elected treasurer of Quantic Industries, Inc.

Richard F. Mills: Appointed vice president-controller at Computer Control Company, Inc. He was formerly controller of Digital Equipment Corp.

Clyde R. Rockwood: Named to a newly created position of director of solid-state development for Whirlpool Corp.'s Research Center.

D. D. Welder: Appointed director of Army and NASA programs for Hercules Powder Co.'s Chemical Propulsion Div. He is director of the *Sprint* program.

Edgar E. Hardy: To join Monsanto Co.'s Research Corp. as director of the Dayton, Ohio, laboratory. He was director of development for Monsanto's Plastic Products and Resins Div.

Dr. Martha J. Thomas: Presented with the 1965 Achievement Award of the Society of Women Engineers. She is one of the few women working in the relatively unknown phosphor research field with Sylvania Electric Products.

Col. David W. Pearsall: Appointed the new Deputy for Advanced Planning for the Electronic Systems Div. of Air Force Systems Command. He was project officer for the first American rocket powered aircraft, *X-1*.

Maj. Gen. Kenneth O. Sanborn: Named Chief of Staff of the Air Force Logistics Command.

Thomas L. Baasch: Appointed to the staff of the Advanced Technology Operations Group of Fairchild Hiller Corp.

F. A. Darwin: Appointed to the position of research and engineering manager-Aerospace Div. of Babcock Electronics Corp.

George A. Stein: Re-elected for a second term as general chairman of the Reinforced Plastics Div. of the Society of the Plastics Industry. He is manager of plastics and plasticizers for the Research Dept. of Archer Daniels Midland Co.

Col. Robert A. Duffy: Presented the 1964 Thurlow Award for outstanding contributions to the science of navigation from the Institute of Navigation.

Andrew G. Haley: Appointed general counsel and legal adviser to the secretary-general of the International Telecommunication Union.

A. Bromley Muller: Joined The Singer Co., Metrics Div. as chief engineer for electrical instruments. He will have charge of design and development of electrical measuring, calibration and standards instruments.

Sverre Petterssen: Awarded the International Meteorological Organization Prize which is given for outstanding work in meteorology and international collaboration.

William H. Berman: Promoted from general attorney to the assistant general counsel of the Communications Satellite Corp. He is a former Atomic Energy Commission and Disarmament Agency attorney.

Kenneth A. Young: Appointed director of public information at Laboratory for Electronics, Inc.

Joseph DiGirolamo: Named resident manager and elected vice president of CTS of Berne, Inc., Berne, Ind.

David Newman: Appointed chief engineer of Polyflon Corp. he was formerly with the Denver division of Martin Co.

Dr. Benjamin Lustman: Awarded by the American Nuclear Society for "outstanding contributions to reactor materials." He is manager of reactor metallurgy at the Bettis Atomic Power Laboratory which is operated by Westinghouse Electric Corp. for AEC.

Murray Kraus: Appointed a vice president of CompuDyne Corp. He is also general manager of engineering.

when and where

JULY

International Astrophysical Symposium, sponsored by the Astrophysical Institute of the University of Liege, Liege, Belgium, July 5-7.

Gordon Research Conferences (Polymers), New London, Conn., July 5-9.

Pricing and Negotiating Prime and Sub-Contracts in the Defense and Aerospace Industries, sponsored by Contract Management Institute, Shoreham Hotel, Washington, D.C., July 6-10.

Eighth Annual Institute in Technical and Industrial Communications, sponsored by Colorado State University, Colorado State University, Fort Collins, July 6-10.

The Impact of Educational Technology, sponsored by American Management Assn., The Americana Hotel, New York City, July 12-16.

Gordon Research Conferences (Chemistry and Metallurgy of Semiconductors), Andover, N.H., July 12-16.

Annual IEEE Conference on Nuclear and Space Radiation Effects, sponsored by the Institute of Electrical and Electronics Engineers, University of Michigan, Ann Arbor, July 12-16.

Advanced Science Seminar in Experimental Techniques in High-Speed Aerodynamics and Gasdynamics, sponsored by the National Science Foundation, Ohio State University, Columbus, July 12-23.

Aerospace Vehicle Flight Control Conference, sponsored by the Society of Automotive Engineers and NASA, International Hotel, Los Angeles, July 13-15.

European Space Symposium, sponsored by Eurospace, in conjunction with the International Exhibition of Transport, Munich, July 19-22.

Second Annual Meeting and Technical Display of the American Institute of Aeronautics and Astronautics, Civic Center, San Francisco, July 26-29.

Aerospace Reliability and Maintainability Conference, sponsored by the American Society of Mechanical Engineers, American Institute of Aeronautics and Astronautics and the Society of Automotive Engineers, Statler Hilton Hotel, Los Angeles, July 28-30.

AUGUST

Eighth Annual Space Technology Institute, sponsored by Air Force Systems Command, NASA, and University of Connecticut, University of Connecticut, Storrs, Aug. 1-13.

Tenth Technical Symposium, sponsored by Society of Photo-optical Instrumentation Engineers and Air Force Systems Command, Jack Tar Hotel, San Francisco, Aug. 16-20.

1965 National Meeting of the American Astronautical Society, Sheraton Palace, Aug. 18-20.

International Lunar Geological Field Conference, sponsored by University of Oregon and New York Academy of Sciences, Bend, Ore., Aug. 22-28.

Conference on the Exploration of Mars and Venus, sponsored by Virginia Polytechnic Institute, NASA, and Air Force Cambridge Research Laboratory, Blacksburg, Va., Aug. 23-27.

1965 Western Electronic Show and Convention (WESCON), San Francisco, Aug. 24-27.

1965 International Antenna and Propagation Symposium, sponsored by Institute of Electrical and Electronics Engineers, Sheraton Park Hotel, Washington, D.C., Aug. 30-Sept. 1

Armed Forces Management Assn. Twelfth National Conference, Washington Hilton Hotel, Washington, D.C., Aug. 31-Sept. 2.

SEPTEMBER

Second Annual Conference on the Effects of Shock and Vibration on the Human Body, sponsored by University of Denver and the Colorado Chapter of the Institute of Environmental Sciences, University of Denver, Denver, Sept. 1-3.

URSI Symposium on Electromagnetic Wave Theory, sponsored by U.S. National Committee, International Scientific Radio Union (URSI), Technological University, Delft, The Netherlands, Sept. 6-11.

16th International Astronautical Congress, sponsored by the International Astronautical Federation, Athens, Greece, Sept. 12-18.

Thirteenth Annual Joint Engineering Management Conference, sponsored by American Institute of Aeronautics and Astronautics, Institute of Electrical and Electronics Engineers, ASME, and others, Roosevelt Hotel, New York City, Sept. 13-14.

Thermophysics Specialist Conference, sponsored by American Institute of Aeronautics and Astronautics U.S. Naval Postgraduate School, Monterey, Calif., Sept. 13-15.

Electrical Insulation Conference, sponsored by U.S. Navy Bureau of Ships and Allis-Chalmers Mfg. Co., New York Hilton, New York City, Sept. 13-16.

Fifth Annual National Conference on Environmental Effects on Aircraft and Propulsion Systems, sponsored by U.S. Naval Air Turbine Test Station, Nassau Inn, Princeton, N.J. Sept. 20-22.

Systems Engineering Exposition and Conference, McCormick Place, Chicago, Sept. 20-23.

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Britain's Choice

LONDON

THE BRITISH TODAY are putting great emphasis on their contribution to the European space programs. This is not surprising, for it is depressingly evident that there is no British national space program worthy of the name.

As we noted last week, the De Gaulle government shows an intelligent grasp of the importance of a broadly based space program to the technological future of France. There is no such awareness shown by Britain's present leaders.

There is a great deal of talk about Anglo-French cooperation in this field, but it is coming almost entirely from the British side of the channel. It takes two to make a marriage and the French display no great interest in such a liaison. The French are cooperating in the European space projects, but they also are pressing ahead with a program of their own.

The bits and pieces of space work in England do not add up to a program, however, and certainly will not do much to ground British scientists and engineers in the fundamentals of advanced technology.

The nation now faces a technological milestone as critical as the one just after World War II, when a decision had to be made on the development of experimental supersonic aircraft. That decision was negative and the British aircraft industry suffers from it to this day.

The decision on space is an equally crucial one. An effective national space program will give Britain the key to tomorrow's technology. Failure to institute one will insure gradual disappearance of the United Kingdom as an industrial leader.

Such a program need not be inordinately expensive. Worthwhile results can be attained without straining toward the scope of the U.S. or Soviet manned space programs. The French are achieving a competence in space for an outlay of $42 million this year, over and above their contribution of some $20 million to the European space projects.

It is evident, however, that certain intangibles must be recognized in the U.K. before even a modest program can be undertaken. One is that development of technology is a worthwhile goal in itself even if immediate financial gain is not forthcoming. The British vigorously pursued civilian nuclear technology even when no immediate payoff was evident. The return is coming now in commercial power stations. The same thing can happen in a space program.

A second is the need in this field for a continuing program not subject to the vagaries of government economy slashes. Only when there is assurance of a program with sound objectives and adequate financial commitment can the British industry develop the necessary competence in space. Generally speaking, the British capability in science is excellent and likely to remain so; the promise of a continuing economic commitment is necessary to hold together engineering teams with a comparable level of ability.

There also is a need for recognition that a space program is comprehensive; it requires a capability not only to design and build boosters and satellites, but also telemetry, guidance and control equipment, data-handling and tracking systems—and to impose efficient systems engineering and management on all of this.

One of the major stumbling blocks to development of such a program in the U.K. is the lack of a single agency or even a single official below the level of Harold Wilson with the responsibility for it. What British space work exists is scattered among a dozen or more government departments as widely diverse as the Post Office and the Defense Ministry. Only at the level of the Prime Minister himself do these many lines converge.

AN IMPERATIVE first step to an effective space program would seem to be creation of a British space agency equivalent to the French Centre National D'Etudes Spatiales or the American National Aeronautics and Space Administration. This would provide an organization to draw up a viable program with properly defined objectives and also establish an advocate for this program in government councils. No such advocate now exists.

This body also could work toward a national appreciation of the importance of developing a capability in advanced technology, something that seems to be lacking in Britain today.

The question arises of what specific projects such a national space program might undertake. A well-planned series of scientific satellites is seen as one approach, to be followed perhaps by more commercial ventures such as a British satellite system for Commonwealth communications.

The latter would promise not only financial return but establish a strong Commonwealth link—which might have more appeal both to the Member of Parliament and the man in the street than a commitment to some of the grandiose schemes of a Eurospace organization already beset by resurgent nationalism.

The cooperation of Britain, Canada, Australia and other Commonwealth countries in such a project not only would have the practical goal of improving communications, but also might stir anew the past glory of that vast commercial Empire which Britain once led so proudly. Communications and trade are closely related; television alone would do much to draw the Commonwealth nations more closely together. Certainly, this is a more practical dream of space achievement for the British than participation in a costly and impractical European project to build an *Aerospace Transporter*.

But none of this will come true unless the Labor Government grasps the importance of a national space program. To date, like its predecessor, it has failed to do so.

William J. Coughlin

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Base Electrical — B.S. in E.E. with 3 to 8 years' experience involving design of electrical power installations, electrical ground cable and missile interconnecting systems, switching and distribution units. Will develop specifications, test requirements and analysis of flight data.

Guidance/Flight Mechanics — Several key, senior positions available demanding 3 to 8 years' aerospace experience with B.S. and graduate work preferred. Assignments will involve technical investigations of trajectory shaping, payloads, sizing, orbit mechanics, staging and launch analysis, penetration aids, stability, guidance concepts and error analysis.

Aerothermodynamics — Join activities of a group concerned with the aerodynamic design, testing and analysis of launch vehicles and strategic weapon systems. Experience in subsonic to hypersonic speeds, ascent and orbital flight, flow problems, verification of calculations, and unsteady loads and pressures. Advanced degree desired with 7 years' applicable experience necessary.

Propulsion Systems — Several senior positions requiring 5 to 7 years' aerospace experience in Liquid Engines or Solid Motors with B.S. required and graduate work preferred. Assignments will involve subsystem design and development, performance prediction and systems integration and testing for advanced, complex space booster systems.

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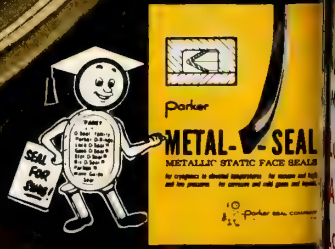

JULY 12, 1965

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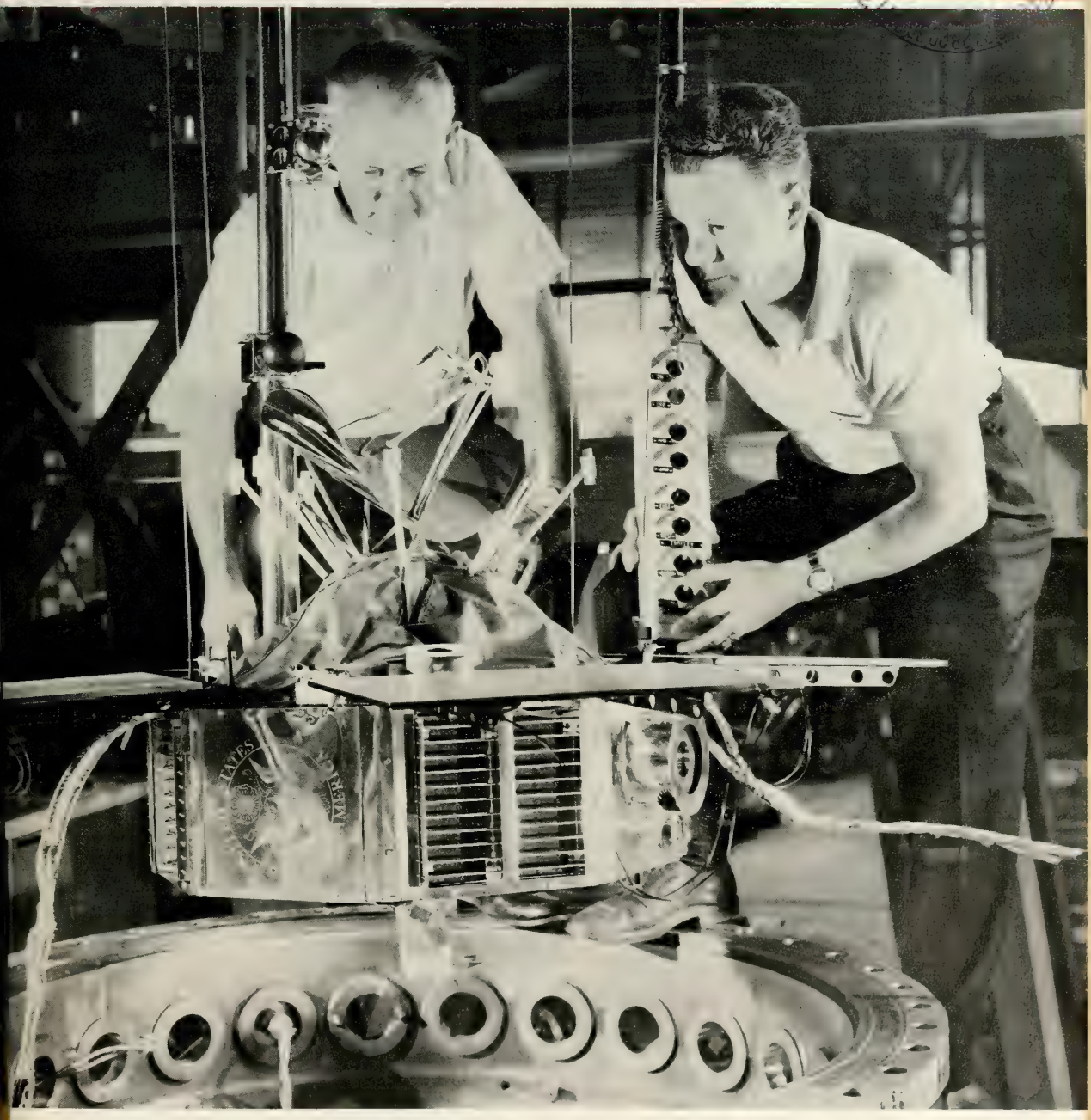

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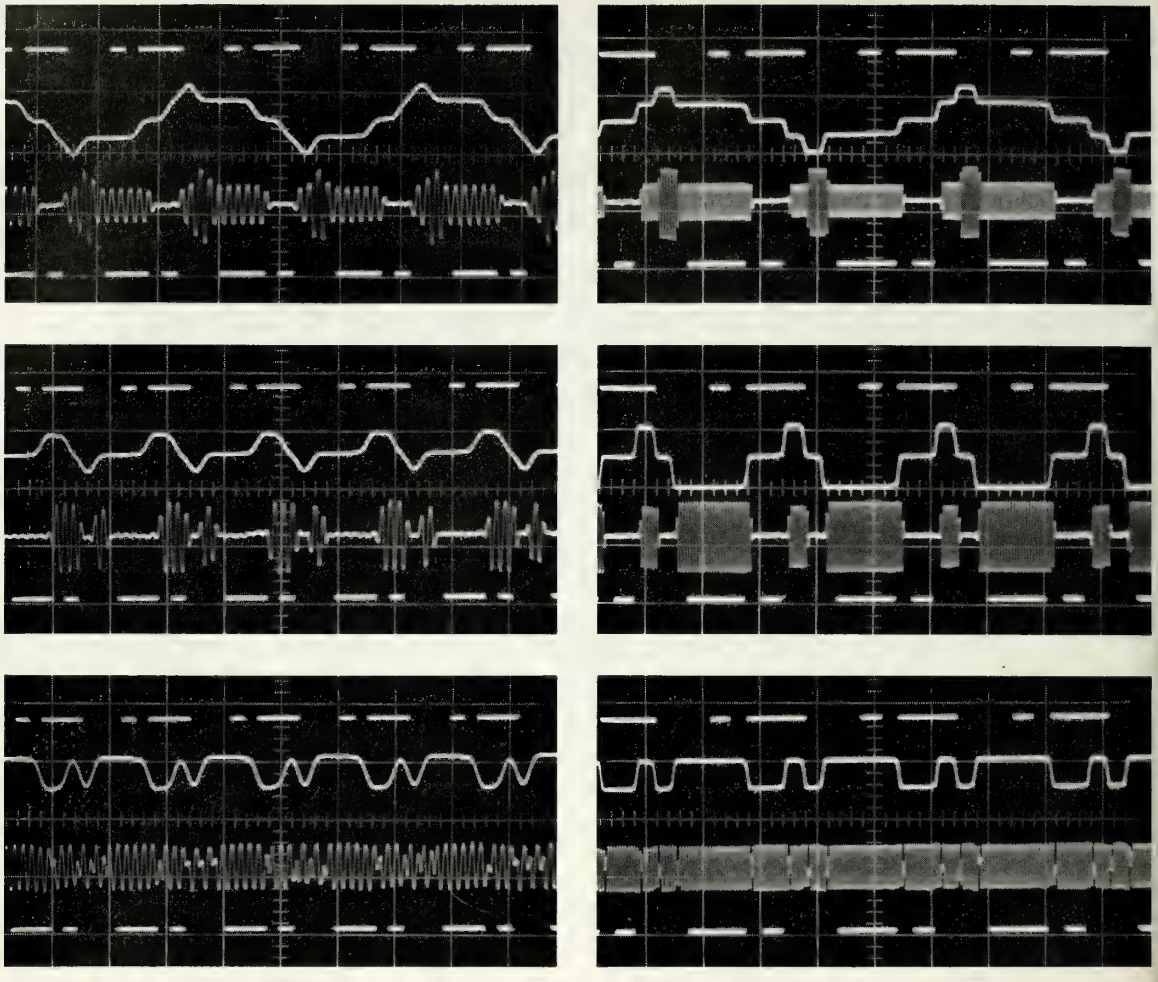

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Our space talk began at the dawn of the space age with the worldwide Minitrack network and grew up with the Mercury, Advent, Syncom, and Gemini systems. We are feeling the pulse of the future through studies on MORL, OSSS, ALSS, LORL, MOL, and Voyager.

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Volume 17, Number 2 July 12, 1965

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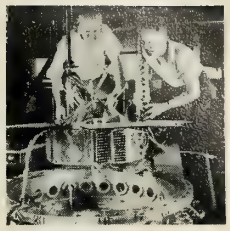

THE COVER

Half-scale model of Mariner Mars spacecraft after being tested in interplanetary space tank at NASA's Lewis Research Center. Tank simulates —453°F of space environment, a pressure 10-billion times less than that on Earth and solar effects of space. See story, page 11.

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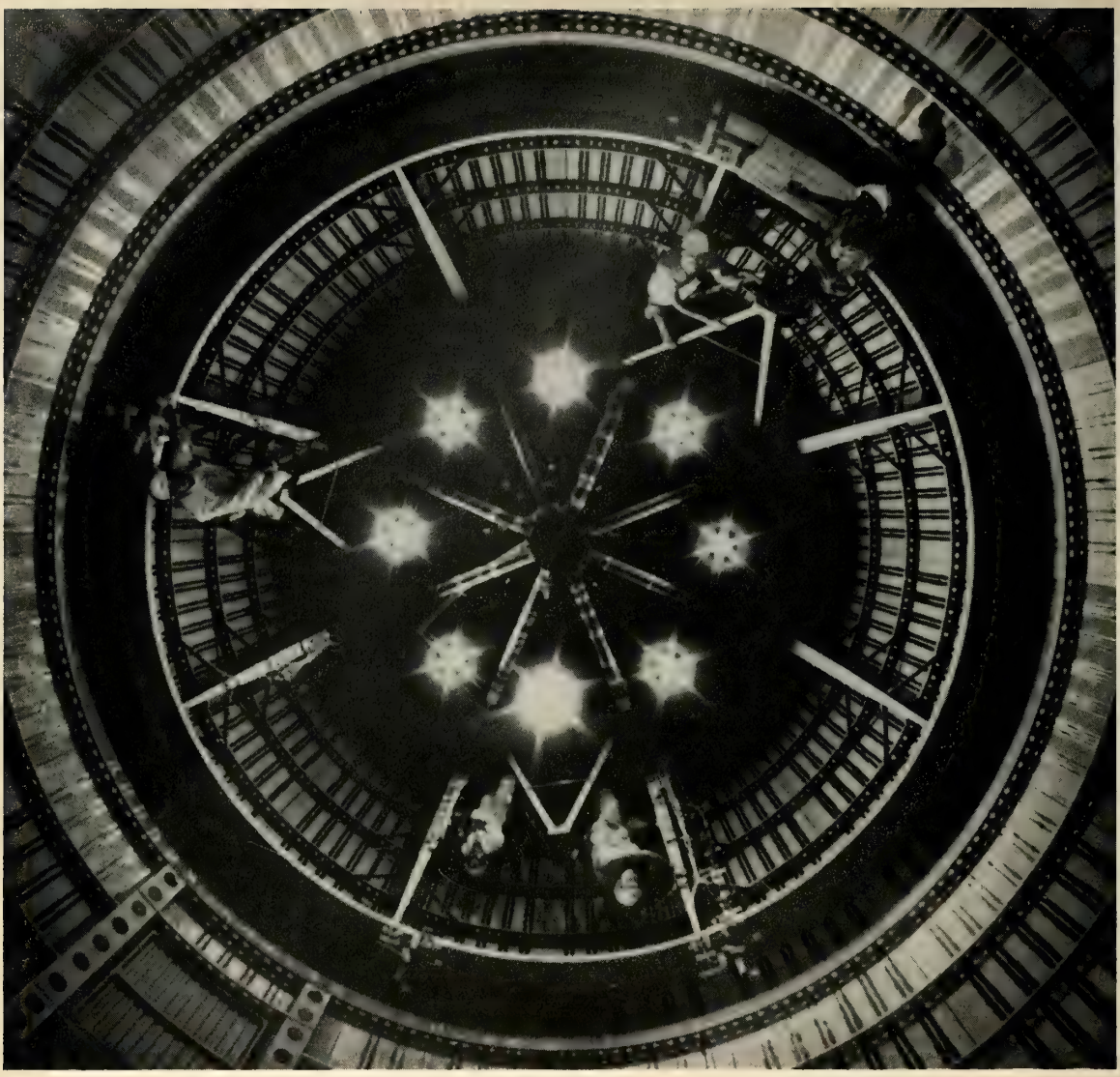

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Ground Support Equipment
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Mathematician
PhD. Help make new, special purpose computers/programs.

Battery Technologists
Design, fabricate, test: High energy density batteries, electrodes, separators, cases, seals, components.

letters

'Fluidics' Is Catching

To the Editor:

As you probably know, the National Fluid Power Association is taking a strong position in the fluid amplifier field (M/R, Feb. 8, p. 18—Special Report on Fluidics). At their last meeting they officially adopted the name "fluidics" for the fluid amplifier technology.

I feel that congratulations are due to your publication for getting an appropriate and accurate name sold.

Richard A. O'Brien
Product Manager–Fluid Devices
Corning Glass Works
Bradford, Pa.

R&D Management

To the Editor:

I have just read Mr. Judson A. Lovingood's statement about being flabbergasted by an M/R article on NASA's Electronics Research Center reporting that a "unique" procedure at ERC will be that laboratory chiefs will actively manage, rather than monitor, industry and university research contracts.

His comment that "In fact, on occasion we have received complaints from some of our contractors for our active participation in the research effort," leads me to consider my several years of R&D "management" in the Defense Department when it was readily apparent that many officials could not differentiate between the manager, the monitor and the meddler.

D. H. Freeman
Concord, Mass.

GT-4 Hatch & Calcium

To the Editor:

Your magazine is most informative and is beginning to be read by many of our members—over 23,000 registered physicians. The MSSNY is the oldest and second largest medical organization in the Western Hemisphere. I personally eagerly read your excellent and frank editorials.

May I take the liberty to ask two questions, hoping you might have some kind of an answer?

Do you have any official knowledge as to the reason for the difficulty in the closing and opening of the hatch of *GT-4?* It so happened that while in Buffalo on a lecture I was confronted with the question on two of the three TV channels, after NBC from Montreal reported that as of 9 a.m. June 4 no reason or explanation could be given by (Manned Spacecraft Center). I stated a half-hour later, and it was announced at 6 and 6:15 that same evening by the undersigned, that cold welding in high vacuum would be the likely cause. Also, the dangers of euphoria caused by weightlessness in open space are similar symptomatologically to the condition called nitrogen narcosis often experienced in scuba diving. There is a common tendency to over/underestimate a foreseen or unexpected situation. (In reference to cold welding, the first announcement came from Walter Sullivan in the *New York Times* reporting from Houston on June 8.)

Continued reference is being made in the U.S. press to loss of calcium due to weightlessness of the cosmonauts. Dr. Gazenko did *not* confirm this to me personally in Chicago in May. Available USSR translations give no positive evidence of this loss due to weightlessness. There are 515 USSR space medicine articles from 1962 to 1964! Do you have any knowledge directly on the subject?

Dr. Constantine Generales
Chairman, Section on
Space Medicine
Medical Society of the
State of New York
New York, N.Y.

1) The vacuum weld theory regarding the GT-4 hatch problem was not "first" announced by the Times, but grew out of a news conference in Houston shortly after the flight. So far, there has been no official report as to the cause; it may be made public this week.

Doctors at the Manned Spacecraft Center say very definitely that there was no experience of euphoria during the flight.

2) Loss of calcium by the cosmonauts due to weightlessness was first reported to M/R by Dr. Stanley White, then of NASA, two years ago. White said at that time that the Soviets had discussed the problem verbally. As far as we know, there is no evidence of the matter in Soviet literature.
—Ed.

Britain's Choice

To the Editor:

Your July 5 editorial ("Britain's Choice") really rang the bell. The UK still has a clear chance, if it will only seize it, to reclaim a leading position in the world technological community.

David Fraser
Montreal

Reprints of NASA Report

Reprints of the entire Special Report on NASA's new Electronics Research Center published in the May 31 issue of MISSILES AND ROCKETS *may be obtained from:*

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SYSTEM ANALYST ENGINEER (NUCLEAR WEAPONS)—Evaluate the vulnerability of Air Force systems to the effects of nuclear weapons. Identify the lethal aspects of postulated enemy nuclear environments which may be encountered during ground alert or airborne phases. Degree in Engineering or Physics is desired. Background should include experience in methods of engineering analysis and knowledge of nuclear weapons effects.

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The Countdown

WASHINGTON

Panels To Be Planted for Astronauts

Space agency officials are putting small, removable panels on the *Pegasus C* meteoroid detection spacecraft for possible collection by orbiting astronauts. Measuring 11 x 18 in., the panels will be attached in such a way that they can be removed easily with simple tools. Four will be fastened to either side of the satellite, for a total of eight. The Fairchild-Hiller satellite is scheduled to be launched on July 30. NASA says that while no decision has been made, it is possible that sometime in the future astronauts will rendezvous with the *Pegasus* and bring the panels back to Earth.

Centaur Launching Deferred Again

New launch date for the *Cenatur 6* flight has slipped to late July or early August. If any malfunctions crop up in a series of tests—including an all-systems test and tank qualification checks—further delay in the launch is possible.

Vela Doubleheader Due This Week

Two *Vela Hotel* nuclear explosion-detection satellites are to be orbited from Cape Kennedy on July 15. Planned firing time is 4:20 a.m. EDT, with a 30-minute window. To be put into orbit by an *Atlas* booster on Pad 13, the satellites will have more detection capability than their predecessors.

Business Picking Up at the Cape

Fiscal Year 1966 promises to be a big one at the Eastern Test Range. NASA plans 31 launches and DOD 116, for a total of 147 major shots. In Fiscal '65, the total was 111. Biggest year to date was 1961, during which there were 203 launches, according to Air Force figures.

Reinartz To Boss Saturn IB/Centaur Shop

Stanley R. Reinartz has been named to head the *Saturn IB/Centaur* program office at Marshall Space Flight Center. It is expected that NASA will begin program definition of the new launch vehicle later this year, despite Air Force claims that the *Titan III* could handle the *Voyager* mission, for which the three-stage vehicle is principally designed.

Outlook Dim for Gemini Land Recovery

While NASA officials still have made no final decision, chances of a land impact on the *Gemini 12* flight are remote. Manned Spacecraft Center officials have complained privately that they can't sell the proposal to anybody. NASA Headquarters says only that it is still being considered.

DOD Values R&D by 'Local Resources'

A study of Dept. of Defense research and development data over the past 20 years shows that many of the best technological developments came from "local resources," or those not specifically directed by higher authority, a top DOD witness told the House subcommittee on Science, Research and Development. A further examination of some 1,000 such developments is under way to determine how contracting policies can be changed or broadened to allow the flexibility that apparently gives rise to such ingenuity.

Change of Command at PMR

Rear Adm. Raymond N. Sharp is replacing Rear Adm. John E. Clark as commander of the Pacific Missile Range, headquartered at Pt. Mugu, Calif. Clark will assume command of the Twelfth Naval District, with headquarters in San Francisco. Sharp, currently director of Field Support Activity, in Washington, D.C., has previously been Senior Naval Member, Military Studies and Liaison Division, Weapons Systems Evaluation Group (WSEG), Dept. of Defense.

Stage Being Set for GT-5 Countdown

Electrical mating of the *Gemini 5* spacecraft with its *Titan II* booster is now in progress at Cape Kennedy. Mechanical mating was carried out on Pad 19 on July 6. The capsule arrived at the Cape on June 19, and was hoisted above the booster June 25. The *Agena* to be employed for simultaneous countdown with *GT-5* was mated with its *Atlas* booster on Pad 14 July 7. It has been at the Cape since May 29. Unofficial launch target date is Aug. 17, but there apparently is a possibility of another week's postponement.

INDUSTRY

Atlas F Support Gear Available

Disposal of $281 million worth of *Atlas F* support equipment is in progress at Lincoln AFB, Neb. Customers are expected to pay only handling and transportation charges. Available are vacuum tubes, transistors, control panels, forklift trucks, generators, instruments, air conditioners, computers, power supplies, tow trucks and many other items. The Air Force owns the merchandise, which is on display in a hangar at Lincoln. Utilization of the equipment must meet rules set by the Defense Supply Agency. Coordination of the program is carried out by the Defense Logistics Services Center, with headquarters at Battle Creek, Mich.

Computers Threaten Nevada Industry

The Fall Joint Computer Conference will be held Nov. 30-Dec. 2 in, of all places, Las Vegas, Nev., it has been announced. Whether the several thousand scientists and engineers attending can devise a foolproof computerized system for outsmarting the gaming tables remains to be seen.

INTERNATIONAL

Japanese Reported Ready for Big Hawk Buy

The Japanese Defense Agency is reported to have decided to arm at least three battalions with Raytheon *Hawk* surface-to-air missiles. The Pentagon declined, however, to comment on reports that negotiations were under way. It's also reported that Japanese crews for three such battalions have been undergoing training at Fort Bliss, Okla. Japan has studied the possibility of licensed manufacture of the missiles, but no decision has been made as to where the *Hawks* will be built. Cost of equipping a single battalion with the weapons is about $22 million.

156-in. Solids To LPC

Lockheed Propulsion Co. has received a $5.5-million contract to develop and fire two 156-in.-dia. flightweight solid motors late this year.

The fixed-price award calls for one segmented motor about 75 ft. in length. It will contain more than 700,000 lbs. of high-performance propellant and produce more than 3-million lbs. of thrust. The motor will consist of a center segment and two end closures.

The segments of the second motor will be welded together to form a monolithic configuration 35 ft. long. It will hold 300,000 lbs. of propellant and generate 1 million lbs. of thrust. A partially submerged nozzle of an advanced type will be featured in the second motor. A thrust-vector-control system employing secondary injection of nitrogen tetroxide gas will be used with both motors, although they will not necessarily be of the same design. TVC systems will use flightweight side-mounted tanks.

Laser Contract Let to RCA

Production of three laser transmitters that will enable a *Gemini* astronaut to "communicate" from space on a narrow beam of light (p. 18) has begun under an $88,657 contract to Radio Corp. of America, Camden, N.J., by NASA's Manned Spacecraft Center in Houston.

The contract calls for delivery of one transmitter to McDonnell Aircraft Corp. by this month or next for inclusion in the seventh *Gemini* spacecraft (fifth manned mission). Two other transmitters will be delivered to MSC.

The transmitters will be equipped with "bite boards" designed to resolve aiming difficulties encountered during aircraft flight tests at White Sands Missile Range, N.M., earlier this year. The astronaut, MSC said, will clamp his teeth on the board to help align the transmitter eyepiece. Handles on each side of the transmitter must be initiated simultaneously to actuate the laser, which will beam the light through the spacecraft window. The bite board modification rules out voice transmission as planned earlier. Instead, the astronaut will transmit a constant signal.

The astronaut will visually aim a beam of light 0.1 degree wide at an IBM-developed pulsing, infrared beacon, employing an argon gas laser atop a receiver at the White Sands Missile Range. The transmitter will be capable of 10 minutes of operation over a 1,000-n.mi. range, according to MSC.

Last Pegasus Shot Set

NASA is scheduled to launch the third and last *Pegasus* meteoroid detection spacecraft from Cape Kennedy on July 30.

A *Saturn I* booster will place *Pegasus C* into a circular orbit about 330 miles above the Earth. The 1.5-ton spacecraft will provide 2,300 sq. ft. of instrumented panel surface to gather data on the frequency of meteoroid strikes.

Pad 37 Pact in Doubt

The Army Corps of Engineers has not yet decided whether to accept the $6,745,000 bid by Blount Bros. Corp., Montgomery, Ala., for Saturn complex 37 modifications or reject all bids and readvertise.

The bid is $1.5 million over the official Government estimate of $5,239,253 for the work, but it was the lowest of five—the highest running $10,495,000.

DOD Officials Named

President Johnson has nominated two men to fill assistant secretary of defense positions created by recent resignations.

Upgraded to assistant secretary of defense, if the Senate concurs, will be Deputy Assistant Secretary for Systems Analysis Alain C. Enthoven. Although one assistant secretary position was vacated by the resignation of Eugene C. Fubini, it appears that the actual position of Deputy Director of Defense Research and Engineering, which Fubini held, will no longer hold the title of assist-

'Anti-Gravity Machine'

RECENTLY ACTIVATED lunar landing research facility at NASA's Langley Research Center provides space agency scientists a controlled laboratory with which to develop techniques for landing the Lunar Excursion Module on the Moon. The research vehicle is controlled by the thrust of its main rockets and a system of maneuvering rockets. The engines are relieved of five-sixths of the weight of the vehicle by the vertical cable system, which is attached to a servo-controlled hoist system in a dolly unit mounted under the travelling bridge, to simulate the ⅙-g gravitational force on the Moon.

ant secretary. Enthoven will continue in his same duties.

The other nomination, an actual replacement, is that of Robert N. Anthony, who Johnson nominated to fill the position and hold the title of Charles Johnston Hitch, former comptroller.

Ford Would Hit Missile Sites

The State Department's revelation last week that missile sites are under construction in North Viet Nam, near Hanoi, prompted Republican minority leader Gerald Ford (Mich.) to call for an immediate attack to destroy them.

Although the sites, which the State Department said were almost completed, are described as being for surface-to-air missiles, Ford pointed out that such sites can easily be converted to longer-range surface-to-surface missile use. He indicated that the possibility cannot be ignored that the sites have a dual purpose, or at least that the potential is there.

The State Department said there were two missile sites almost ready to receive weapons, and that two others were nearing completion. It was conjectured widely that the North Vietnamese plan six sites, around Hanoi and Haiphong.

Ford said he had no information as to what the Administration planned to do about the sites, but he felt they should be destroyed before they can be used. He largely discounted the possibility that they were purely defensive in purpose.

The minority leader said there was increasing evidence of outside support to the North Vietnamese from the Soviet Union and from Red China. He gave as an example the building of airports, which are for aircraft more sophisticated than those yet used by the North Vietnamese.

Support Contracts Worth $16 M

Goddard Space Flight Center is negotiating with six firms for scientific and engineering support services at 10 of its divisions.

Total cost of the cost-plus-award-fee contracts is estimated at $16 million. A 1-year extension would increase the total to about $23 million. The selected contractors will have total responsibility for specified tasks in each area of work. Although requirements of a single division will be fulfilled through a single contract, one contractor might service more than one division.

The awards include: Fairchild-Hiller Corp., Hagerstown, Md., $5 million; Vitro Corp. of America, Silver Spring, Md., $3.33 million; Electro-Mechanical Research, Inc., College Park, Md., $2 million; Consultants and Designers, Inc., Arlington, Va., $1.5 million; Lockheed Electronics Co., Clark, N.J., $2.5 million; and Melpar, Inc., Falls Church, Va., $1.75 million.

Welch To Leave Comsat

Leo D. Welch, chairman and chief executive officer of Communications Satellite Corp., plans to resign his position as soon as a successor can be found.

Welch informed the Comsat board of directors on May 21 that he wished to retire and "slow down" his pace of activity. The group reportedly has been screening candidates for the post.

Shots of the Week

Tiros X, the first satellite to be funded by the Weather Bureau, was launched from Cape Kennedy on July 2 aboard a *Delta* vehicle. The meteorological satellite encountered trouble early in the flight when its de-spin rockets failed to fire automatically, but a backup radio signal succeeded in activating the rockets. Goddard Space Flight Center received the first properly oriented photos from the metsat on July 6.

- The Air Force launched an *Atlas D* ICBM from Vandenberg AFB, Calif., on July 1 in support of the Army's *Nike-Zeus* anti-ICBM program.
- The Soviet Union launched the scientific satellite *Cosmos 70* on July 2. Initial period was given as 98.3 minutes; apogee, 717 mi.; perigee, 142 mi.; inclination, 48.8 degrees.
- The Air Force fired a *Minuteman* ICBM from Vandenberg AFB, Calif., on July 2.

New Facility at Goddard

A magnetic facility to calibrate spacecraft instruments designed to measure the low magnetic fields of outer space is now in operation at NASA's Goddard Space Flight Center.

The Magnetic Field Components Test Facility is also equipped to demagnetize spacecraft carrying the measuring instruments. The system contains a three-axis coil system consisting of four electrical loops on each axis, which enclose a sphere measuring approximately 20 ft. in internal diameter.

The selected magnetic field can be held to within a half gamma of the set value inside a 3-ft.-dia. sphere in the center of the controlled area.

IMPORTANT OPENINGS FOR ENGINEERS AND SCIENTISTS ON AMERICA'S MAJOR SPACE PROGRAMS

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LEM descent engine
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TRW SYSTEMS

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Lunar Exploration Systems Advance

Space agency close to selecting contractor for Surveyor-borne small rover; studies extended for longer-duration modified LEM

by Hal Taylor

THE SPACE AGENCY has taken two major steps leading to the development of both unmanned and manned roving vehicles for extended exploration of the Moon.

In the unmanned area, a source selection board has made its recommendation on a contractor to develop a small roving vehicle that would be carried to the lunar surface by the *Surveyor* spacecraft. Announcement of the winner is imminent.

The award—with only Bendix and General Motors competing—will be worth $30 to $40 million.

In the manned area, the Marshall Space Flight Center has extended prior study contracts of the *Mobile Laboratory (MOLAB)* with The Boeing Co. and Bendix to include systems definition of the use of a modified Lunar Excursion Module capsule for long-duration exploration of the Moon following the first manned landing. The vehicle, which is called the *Local Scientific Survey Module (LSSM),* would be used for short range (up to five miles) reconnaissance of the surface.

The *Surveyor* roving vehicle will weigh only 100 lbs. It will carry TV cameras and instruments to measure the bearing strength of the Moon's terrain.

● **Launch targets**—It is expected that such a vehicle will be launched on each of the last seven *Surveyor* flights, with the first mission scheduled for 1967. The vehicles will also carry communications equipment that would be used to send the data collected back to the *Surveyor* so that it could be retransmitted back to Earth.

It is not known whether the vehicle will carry a small isotopic nuclear power supply. A study of its use was completed last September and the results reportedly were favorable.

The move to study the use of an *LSSM* is the first step in development of the system that would be used to extend astronaut staytime on the Moon up to two weeks in *Apollo Extension System* missions.

Since NASA officials declared last year that consideration of development of the *Mobile Laboratory (MOLAB)* would not be initiated until later in this decade, the shift of funding to the *LSSM* implies that this is now the favored method for early exploration flights. A final decision is not expected until the spring of next year.

● **Money considerations**—Funding for hardware development will be included in the Fiscal Year 1967 budget.

Boeing will receive $565,000 and Bendix $570,000 for studies of *LSSM*. Both contracts will run for about nine months.

The two firms have completed individual studies of a lunar mobile laboratory under the original terms of the contract. The *MOLAB* would be much larger than the *LSSM* now in study.

The smaller vehicle would not have an enclosed cabin. The astronaut would sit in the open, wearing his spacesuit and using his back-pack life-support equipment while exploring within a short radius of the LEM shelter.

The *LSSM* would also provide a means of moving scientific equipment about the Moon's surface. Major systems of the *LSSM*, which would weigh between 800 and 1,500 lbs., include mobility, power, crew station, communication, control and navigation.

● **Two travel modes**—In the LEM shelter concept the astronauts would explore afoot within a short radius and use the *LSSM* for trips within a five-mile radius. Beyond five miles they would be below the horizon. This would present line-of-sight communications problems.

For exploration up to 15 mi. from the shelter or for reaching sites inaccessible afoot or by *LSSM,* a manned flying system (MFS) for one or two astronauts is being considered as another part of the broad lunar exploration study.

Textron's Bell Aerosystems Co. developed a preliminary design concept of such a flying vehicle during a 12-month study. The vehicle would be about the size of an average desk and would have an open cockpit above the propulsion unit.

Five 100-lb.-thrust throttleable rocket engines would provide lift and propulsion. Six attitude control rockets would be used to steer the four-legged, 400-lb. vehicle on trips as long as 50 miles.

Bell has been awarded a follow-on $489,898 contract to design a manned flying system capable of carrying one astronaut-scientist and 300 lbs. of scientific equipment, or two astronauts, on a shorter round-trip—up to 15 mi. from the LEM shelter.

General Motors and Bendix received contracts two weeks ago for producing mobility test articles (MTA) of a lunar surface vehicle. General Motors' 11-month contract is for $389,528 and the Bendix 8-month contract totals $399,-500.

The General Motors and Bendix mobility test articles will have different kinds of wheels. The General Motors vehicle will have six wheels and the Bendix model four.

The MTA's will be used to test both the *LSSM* and *MOLAB* concepts. ■

Cold Launch of ICBM's Pondered

A COLD-LAUNCH concept may be applied to both existing and future solid ICBM's as a result of an Edwards AFB research and development test that proved the feasibility of launching very large missiles from silos using the technique.

Spokesmen for the Air Force Ballistic Systems Div. were enthusiastic over results following the test, conducted by the Air Force Rocket Propulsion Laboratory June 25.

A 160-ton boilerplate missile filled with 300,000 lbs. of water and five times the weight of a *Minuteman* was hurled 150 ft. high out of a *Minuteman* silo. It was tethered with nylon ropes, causing it to veer and fall 200 ft. away. The 10-ft.-dia., 70-ft. dummy was ejected by a free piston, or sabot, a metal saucer on which it was placed at the bottom of the silo. The dummy and an 8,000-lb. sabot were ejected by hot gases from several *Zuni* and *Mace* solid motors in the silo bottom. The ICBM would be ignited after cold ejection.

The Air Force cited advantages, including no misisle ignition in the silo, eliminating exhaust ducts and silo damage and permitting greater utilization of silo space for much-larger-diameter missiles.

Mariner Nears 'Moment of Truth'

Successful transmission of Mars photos would provide valuable Voyager design inputs; two primary experiments detailed

THE U.S. THIS WEEK will attempt the first closeup inspection of Mars when the *Mariner IV* spacecraft passes within 5,700 mi. of the planet July 14.

If it is successful, it will transmit back to Earth the first TV photos of the red planet and provide valuable data for use in design of the *Voyager* spacecraft, which will land capsules on Mars beginning in 1971.

Twenty-one pictures are slated to be taken by a single camera. An occulation experiment, it is hoped, will provide important new data on the Martian atmosphere necessary before the *Voyager* landing capsule design is frozen. Both experiments will be activated shortly before encounter.

By 7:50 p.m., EDT July 14, scientists expect the spacecraft to make its first sighting contact with the planet. The telemetry system should then shift and begin sending only information from the scientific experiments. After a wait of 12 min., the time it takes for radio signals to reach Earth from 134 million miles away, these events should be verified at 8:02.

Aided and guided by the wide-angle sensor, the narrow-angle sensor on the spacecraft then takes over in the final minutes of the planet encounter, and at 8:20 p.m., EDT, the planet should be in full view and the 25-min. picture-taking sequence should begin.

● **Photo targets**—If all goes well, the first two pictures will cover a part of the brightest of Martian deserts, Elysium, and an unusual maria region, Trivium Charontis. This region is unique because it was only recently discovered to be a strong radar back-scatterer—a region that reflects radar waves as a mirror reflects light.

The television camera will then sweep southward across the desert Zephyria and into Mare Cimmerium. Farther south, over the desert Electis, an atmospheric haze that surrounds the polar cap at this time of the Martian year should be encountered. It is hoped that the camera will cut through this haze sufficiently to allow observation of the edge of the polar cap at 55° south latitude. The TV scan will continue in a southeasterly direction, across the termination line south of Aonius Sinus to the polar cap.

The spacecraft will be at an altitude of about 7,000 mi. for the first pictures. The ground resolution will be best near the middle of the television pass when the camera will be pointed almost straight down at the planet. In this region, each picture will cover a surface area 120 by 120 mi., and it should be possible to resolve prominent surface markings as small as two miles across.

The picture-taking sequence is scheduled to end at 8:45 p.m., EDT. Shortly after 9 o'clock, *Mariner* will be at its closest to the planet.

While scientists are eagerly studying the early indications of the planetary scientific experiments and the photographic mission, others will be absorbed with the occultation experiment, the receiving of radio signals from *Mariner* that travel through the Martian atmosphere. Changes in frequency and strength of signal may help determine the density and depth of the Martian atmosphere.

Other experiments aboard *Mariner IV* will seek to detect and measure the planet's magnetic field; any trapped radiation belts such as Earth's Van Allen belts; the extent of cosmic dust (micrometeors) in the near-Mars region, and solar wind around the planet.

● **Performance to date**—*Mariner IV* set a world space communications distance record April 29 as it reached a straight-line distance from Earth of 66 million miles. Soviet scientists reported loss of radio contact with their *Mars I* spacecraft March 21, 1963, at a distance of more than 65 million miles.

Design of the *Mariner* series of spacecraft began in 1961 and *Mariner II* completed the world's first successful trip to Venus Dec. 14, 1962. The *Mariner II* mission yielded 111 million bits of information on interplanetary space and Venus.

Its data indicated the planet's surface temperature to be about 800°F with a temperature range of minus 30° to 70° at the tops of the clouds that surround and shroud the planet. ■

Air Force Tests Possible Gemini Maneuvering Unit

THE AIR FORCE'S Modular Maneuvering Unit (MMU) performs a roll during first flight tests in weightlessness aboard a KC-135 aircraft at Wright-Patterson Air Force Base. The MMU is being "flown" by Lt. Daniel Seger, MMU project engineer for the Aero Propulsion Lab at Wright-Patterson. Twelve jets can propel the wearer forward, backward, up or down. An attitude control system stabilizes the astronaut automatically in pitch, yaw and roll. The MMU is one of several devices developed by the Air Force Systems Command for possible use in the NASA Gemini program. This unit was built by Ling-Temco-Vought, Inc.

Titan III Family May Fill Atlas Silos

ICBM version or booster minus strap-ons proposed by Martin as space reconnaissance vehicles, space rescue ferries

by Donald L. Zylstra

DENVER—Addition of the *Titan III* family of boosters to the nation's space inventory has emphasized a temporary "payload gap" and at the same time has taken the wraps off a number of concepts held back for lack of a satisfactory booster.

The spectacularly successful first launch of the *Titan III-C* (M/R, June 28, p. 14), plus the official retirement of *Atlas* missiles from the Strategic Air Command last month seem unrelated events at first glance. But new emphasis has been given to the military missions possible with *Titan III*, exclusive of its initial function as a multipurpose utilitarian booster—equally useful in military and civilian roles. Such military missions in many cases are best launched from survivable, hardened silos.

In view of the military missions made possible by the development of the *Titan III* booster family, it was no surprise that the Martin Co. was awarded an Air Force Systems Command Ballistic Systems Div. (BSD) contract to study the feasibility of converting 68 *Atlas F* hardened silos to accommodate the *Titan II* and *Titan III* missile and booster systems. Work on this contract was completed in January, 1964.

The *Titan III* Integration, Transfer and Launch (ITL) complex at Cape Kennedy is admirably suited for eventual launch of the Air Force *Manned Orbiting Laboratory* (*MOL*) and multiple launches of communications and experimental satellites. It also has the capacity to take over the NASA *Surveyor* launch in a backup role if the *Saturn IB* with *Centaur* as an upper stage is not ready in time. But there are other situations in which the ITL facility would not serve as well as hardened silos.

● **Missions foreseen**—In outlining such instances, Robert S. Williams, director of strategic systems at Martin Co.'s Denver Division, cites possibilities for developing the basic ICBM design or the *Titan III* booster concept as advanced space reconnaissance vehicles, communications satellites, space command and control systems, space rescue systems, ferry vehicles and re-supply systems.

Such systems would require either the survivability features provided by a hardened silo or the very-short-alert features characteristic of systems ready in dispersed silo locations—or both. For instance, a reconnaissance system designed to meet the needs of a nuclear attack might require both survivability and short-alert features beyond the needs of conventional peacetime reconnaissance vehicles—particularly if it were designed to provide U.S. commanders with speedy information as the basis for launching a second strike in a nuclear exchange.

Military communications vehicles might or might not require protected silo launch sites, depending on their missions. Command and control devices could benefit in numerous ways from pre-launch protection afforded by silos.

Space rescue vehicles would nor-

Titan III Pays Payload Penalty for Reliability

DURING THE ENTIRE design and development process for the *Titan III* booster and its Transtage, the emphasis was on maximum reliability and an attempt to keep the payload integration complexity to a minimum.

Thus, battery power supplies and control modules that might have been placed on each of the system's solid and liquid stages were purposely combined and located in the Transtage—a move in favor of added reliability, with an acknowledged penalty in terms of payload. Had they been individually located in each stage, payload capacity in the Transtage could have been saved, since individual power pack and control modules would have been jettisoned at stage separation.

But Martin designers chose the reliability route by extending power and control leads to the various stages from a combined power and control module. Another design decision involved eliminating slip-ring transfer of power to the gimbaled gyro platform, and depending instead on a cable transfer method which permits gimbaling through 390° but requires an automatic de-pitch maneuver after every orbital pass, since Transtage is designed to present a constant "look," or attitude, toward the Earth throughout each orbit.

● **Payoff**—The de-pitch feature has its bonus aspect in that it can be halted at any point for separation or ejection of multiple payloads—for instance, in an attitude 90° to the vehicle's orbital course, 180° from its direction of progress, etc., to insure adequate separation of payloads, or even a patterned dispersion into predictable positions in space.

This facility will be used to advantage in the orbiting of a series of eight military communications satellites in each of the fourth, fifth and sixth scheduled test launches of the *Titan III-C* development system.

During these launches, power will be conducted across the interface between the Transtage and the payload to blow explosive squibs launching each of the eight satellites, and 37 channels of instrumentation are also planned. Transtage's control system will provide small velocity-increase increments after ejection of each of the satellites to assure proper positioning in space in an apparently random but actually planned injection into orbit, calculated to keep a proper dispersion of the ultimate number of 24 satellites for the longest possible time.

The third *Titan III-C* launch, scheduled for late this December, contemplates as many as a dozen Transtage restarts following the orbiting of two *LES* experimental communications satellites and the *OV2-3* vehicle. This series of restarts is preparatory to the launch procedure for the communications satellite vehicles on the next three test flights.

mally not require special hardening protection, but, in many instances, a vehicle launched from an adapted *Atlas* silo could speed on its rescue mission to humans in orbit in less time than one launched from Cape Kennedy, simply by virtue of its geographic location. Vehicles engaged in ferry missions would normally not benefit from silo launch, nor would logistics vehicles, unless an enemy considered their missions vital enough to make their launch sites worthwhile targets.

Martin planners and engineers compare the *Atlas F* silos to Navy capital ships "which normally undergo several useful conversions over their 20-year life span." They can be converted, either to accommodate improved missile and penetration systems of the future or as military space system bases.

In this role, the dispersion of *Atlas F* sites across the continental United States offers launch position advantages for many space missions, including surveillance and reconnaissance, speeding satellite inspection or interception, and a variety of other military missions requiring prompt rendezvous.

Weapons designed for these missions, dispersed in already existing silos, would aid materially in fighting the war of "controlled response" advocated by Defense Secretary Robert S. McNamara and Pentagon military chiefs.

● **Advanced ICBM's**—Martin scientists and engineers note that mission capabilities and requirements for U.S. missiles will continue to grow and develop. To prepare for this "third generation" development, they are convinced that the nation should build larger payload-carrying potential into a significant portion of its ICBM fleet—against the day when the Soviets or other potential enemies may develop defensive systems requiring more advanced, sophisticated penetration aids, including electronic jamming equipment, decoys, multiple warheads in clusters and maneuvering warheads, and high-speed re-entry systems.

The *Titan* family is the missile and booster concept best equipped to handle the larger payloads that will inevitably be needed to accomplish these missions, in the Martin view. For instance, a *Titan III-A* vehicle, without the solid strap-on motors of the *Titan III-C* version, or the non-man-rated *Titan III-X* now being developed could both be readily accommodated in *Atlas F* silos.

In efforts to augment the performance and payload of the *Titan* booster family, Martin last year completed its version of a BSD-funded study of the performance characteristics of thixotropic metallized gel fuels to replace current storable liquids in *Titan II*.

A *Titan III-M* (the designation being applied informally to the advanced propellant version under study for future development)—without the Transtage but equipped with a guidance and control section just above the second stage—would fit into an *Atlas F* silo leaving space for a payload section about 35 ft. long. Similar dimensions would apply to the *Titan III-X*.

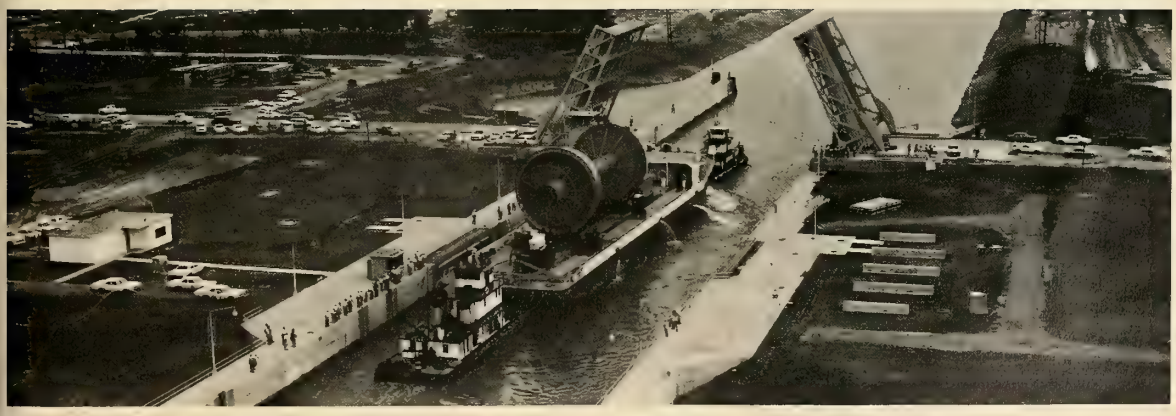
The *Titan III-A* configuration with its Transtage would also fit readily into the silo, leaving generous space (about 25 ft.) for a payload atop the vehicle.

● **Propellant studies pondered**—BSD development people are studying Martin data evolved from the gel propellant study completed in June, 1964, and are awaiting completion of a companion Defense Department contract with Aerojet-General Corp. now nearing completion. This study has already generated data on the feasibility of developing a full-scale uncooled gel propellant engine. Results from demonstration of the feasibility of a full-scale regeneratively cooled engine are now being awaited.

Results of the Martin studies of the firing of metallized gel propellant in a one-twelfth-scale *Titan II* model indicate that the hydrazene (N_2H_4)-and-aluminum powder gel fuel will provide performance permitting doubling of the payload of *Titan II* and *Titan III-A*.

With gel fuel in the core section and 156-in. two-segment strap-ons, engineers calculate they can double the *Titan III* payload also. Gel fuel in the static state remains motionless in its tank, but, under pressure or pumping, it flows as readily as conventional liquid.

Convinced that DOD will follow successful *Titan III* development with significant expansion of military space activities, technologists from Martin and other aerospace industries are vigorously studying ways of increasing booster and missile performance, without making the systems themselves larger or significantly more expensive. ■



NASA'S Mississippi Test Facility Inaugurates Waterway

THIS AERIAL SHOT shows the National Aeronautics and Space Administration's Mississippi Test Facility opening its man-made waterway system to receive its first space age cargo—an S-II Saturn V second-stage simulator built by North American Aviation, Inc. The S-II simulator is shown aboard the river barge Pearl River leaving the Mississippi Test Facility lock. The stage and the Pearl River were lifted some 13 feet in the lock and transported to the test facility's booster storage building. The simulator will be used to check out test stands and other installations at the Mississippi Test Facility. The facility will also be used for test firings of the S-IC first stage of the Saturn V built by Boeing Co. and the Douglas-built S-IVB stage. The Mississippi site is scheduled to become operational sometime next year.

No EVA in Next Three Gemini Flights

Life support dictates of long-duration GT-5, GT-7 missions limit space for experiments; GT-6 will stress rendezvous

THERE WILL NOT be any extravehicular activity in the next three *Gemini* manned space flights.

Spokesmen at the Manned Spacecraft Center said that no technical problems prevent EVA, but that NASA has decided to rule it out primarily because of the extensive life-support requirements of the 8-day *Gemini 5* mission and the planned 14-day *Gemini 7* flight.

Gemini 6 will be a two-day mission, but the prime stress will be on achieving the first rendezvous and docking with the *Agena* upper stage.

Gemini 5 is now scheduled for the third week in August. *Gemini 6* will probably be launched in October, and it is possible, but not probable, that the *Gemini 7* flight could be made in December. The latter flight might not take place until early 1966.

The lack of EVA plans was learned as NASA introduced the *Gemini 7* flight crew, astronauts Frank Borman and James Lovell.

"The prime objective is to spend two weeks in space," Borman explained. He added that the length of the mission will depend on the results of the *GT-5* flight. The eight-day mission is now scheduled to begin Aug. 19.

"All the medical experiments proposed for *Gemini* will be included in this mission," Lovell said.

● **Gemini 7 experiments**—One, a calcium balance study, will measure the rate and the amount of calcium lost through body fluids over the 14 days. Another, repeated from *Gemini 6*, will measure physiological "cost" stress of orbital flight through hormone analyses of urine samples. More than 100 samples of urine will be collected during the flight and compared to pre- and post-flight specimens, Lovell said. Other medical experiments repeated from earlier missions will be:

—Cardiovascular reflex exercises to prevent blood from "pooling" during weightlessness. Pneumatic cuffs on the astronauts' upper arms and thighs will be inflated to approximately 50 mm. of mercury pressure for about five minutes every four to five hours.

—Phonocardiogram reading. A small microphone will be taped to each astronaut to record heart sounds in the biomedical tape recorder simultaneously with his electrocardiogram. Doctors hope to detect muscle action of the heart and its changes, which might indicate heart muscle deterioration as a result of weightlessness.

—Bone demineralization. NASA doctors are evaluating a technique that may help show calcium loss in bones of astronauts as a result of weightlessness over long periods of time. The heel bone and the end bone of the fifth finger, right hand, will be X-rayed before and after the *Gemini* flight and compared for changes in bone mass.

—Electroencephalograph readings. This is an attempt to measure levels of consciousness and depth of sleep over the 14 days. Doctors hope to correlate sleep depth with pilot alertness and pilot performance.

—Vestibular effects. The crew will take turns at attempting to align a white line along the pitch axis of the spacecraft. The astronauts will wear special goggles that block out all other visual cues.

● **Exercise planned**—Both pilots will exercise with the bungee cord, the in-flight exerciser used during the *GT-4* flight. "We will exercise during planned periods each day to try to keep in fine shape," Lovell explained.

Among the 20 experiments scheduled for the *Gemini 7* mission, one will attempt space-to-Earth communications via a beam of light. Lovell will aim a gallium arsenide laser transmitter at a receiver placed alongside an argon gas laser beacon at White Sands Missile Range, N.M.

Borman will attempt to rendezvous with the second stage of the spent *Titan II* booster, or with "another vehicle," possibly the *Agena* target vehicle left in space from the *Gemini 6* rendezvous mission. He pointed out, however, that rendezvous with the *Agena 6* would require considerable ground coordination to try to match the launch day inclination angle.

The *Gemini 7* spacecraft, without rendezvous radar, will not attempt to dock with the *Agena*, he said. ■

Saturn V AGE Takes Shape

JOURNEY to the Moon will begin at one mile per hour, operational speed of crawler-transporter shown here moving down crawlerway at Cape Kennedy carrying mobile launcher #3. A second crawler will be included in Saturn V aerospace ground equipment needed to move vehicle to Launch Complex 39.

Senate Weighs Three Patent Measures

Long amendment, strongly opposed by DOD and Administration, would prevent NASA's waiving rights; other bills described

THE SENATE is moving towards a decision on a Government-wide patent policy which will determine exactly what rights contractors have towards inventions developed before, during—or indirectly from—government-funded research and development.

Three bills are now being considered. Any of them, if adopted, could become the National Inventions Act, or Federal Inventions Act.

Although patent bills have been introduced in Congress for a number of years, the pressure being brought by Sen. Russell B. Long (D-La.) to get his own amendment attached to various agencies' bills is forcing some action this year. When the NASA authorization was brought to the Senate floor, Long's amendment to keep NASA from waiving patent rights was tabled only after the promise that a definitive, Government-wide policy would be adopted this year.

A bill will be offered shortly in the House as well.

● **Present situation**—At the present time, patent ownership actions by Government agencies are governed by the patent policy memorandum issued by President John F. Kennedy on Oct. 10, 1963. This policy incorporated a great deal of flexibility on the part of the agency heads, allowing them to waive patent rights before negotiating a contract under certain circumstances, such as when the work would be based upon inventions already made by the contractor.

However, the practices which have ensued from this policy, and from an additional memorandum issued by NASA in September, 1964, which set down the standards which would govern the use of the patent waiver authority, have led to charges by Long, Sen. Lee Metcalf (D-Mont), and a few other lawmakers that NASA is conducting a wholesale giveway of rights which should belong to the public.

● **Long amendment**—The clause which Long has sought to attach to several bills this year is S-1899, which would require the Government to take title to all inventions and patents emerging from Federally financed research or performed by Federal employees. It does contain provision for review after the contract, to determine whether the contractor should in fact have title to the patent. However, it has been strongly opposed by the Dept. of Defense on the basis that the review is an exceedingly cumbersome administrative process. According to Deputy Assistant Secretary of Defense John Malloy, the requirements which would have to be met before a contractor could obtain title to his invention are such that in practical terms "no patents would be acquired by contractors."

● **McClellan bill**—The bill drafted by Sen. John McClellan (D-Ark.), who chairs the patent subcommittee of the Senate Judiciary Committee which is studying the problem, is backed by DOD, NASA, and other organizations —provided it is amended slightly.

McClellan's bill generally follows President Kennedy's patent policy statement, spelling out a little more specifically the requirements which must be met for waivers, licenses and other provisions. Rep. Emilio Q. Daddario (D-Conn.), chairman of the patents subcommittee on the House Space Committee, said that he will introduce legislation similar to this bill in the House this session.

Another bill, S789, introduced by Sen. Leverett Saltonstall (R-Mass.), is considered similar in intent to the McClellan bill. DOD feels, however, that it does not go far enough.

● **DOD attitude**—Malloy indicated to subcommittee that the mainspring of patent policy in DOD is incentive, and he said bills such as the Long amendment would kill it.

He pointed out that DOD has not generally needed to have full title to contractor's inventions, and has believed that requiring full title would undesirably dilute a necessary incentive for Defense work.

The Long amendment, he said, would have severely adverse long-range effects on defense R&D, tending to concentrate work in only those firms which take DOD contracts on any terms they can get them, and to cut defense work off from the best research work carried on by U.S. companies for their own commercial purposes. He added that it would discourage inventive small businesses from working for the Government.

Malloy, in answer to a committee question, said that he strongly felt that the Government's interest would suffer most because it would not get the research programs handled by the very best research contractors.

Recurrent theme among those objecting to the Long amendment is the fear that a firm which is given a contract because it has done pioneer work in a certain field would no longer bid for such contracts, since it would have to give up all its rights to the knowledge it had acquired before.

Charles L. Shelton, representing the Aerospace Industries Association, said the Long amendment would make industry shy away from accepting such contracts, and it would "dry up" profitable cross-feeding between Government and commercial research.

A spokesman for the American Patent Law Association told the committee in no uncertain terms that "Government, by the policy personified by the Long bill and various Long amendments to specific instances of Government research legislation, is insisting on getting more than what it pays for." He also endorsed McClellan's measure, with reservations.

● **Daddario testimony**—Daddario told the committee that he was convinced that both Government and contractors have logical and justifiable equities in ownership, and that it was "unrealistic to assert that a contractor, who may have contributed as much or more than the government in terms of know-how and the expenditure of its own money . . . has no claim to ownership nor the exclusive right to utilize the patent for commercial purposes."

NASA Administrator James E. Webb said earlier that experience shows that the advance waivers serve both equity and the public interest, and that they especially encourage reporting of patentable inventions by the contractor.

● **LBJ special?**—There is some conjecture that President Johnson may have legislation of his own drafted to set up a Government-wide patent policy.

Of the three bills presently being considered in the Senate, one (McClellan's) is based upon President Kennedy's patent policy and is repeatedly lauded by agency heads for that reason, another was drawn up by a Republican (Saltonstall) and the third (Long's) is considered by the Administration to be totally unacceptable. ■

ENGINEERS AND SCIENTISTS

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Technical Countdown

ELECTRONICS

French Laser Developments Outlined

Several new laser applications are being explored by scientists at the Compagnie Générale d'Electricité's Research Center located just outside Paris. Researchers are experimenting with use of high-energy lasers to initiate sparking action for other high-power equipments. Scientists find that the lasers are extremely accurate in this role in terms of timing and also contribute to safety by removing requirements to have personnel close to the sparking action initiation. Also, at CGE, scientists are pressing research in use of lasers as atom smashers, seeking to develop units that operate at frequencies in the region of the internal atomic frequencies. CGE scientists feel they are among the leaders in the technology in this field. . . . CGE engineers have also built, and are expected to market in the near future, a cleverly designed portable laser laboratory. The equipment consists of two racks roughly 5 ft. high. One unit contains five different laser gases—helium, neon, argon, krypton, and xenon—and pumps. The other rack contains the RF excitation source able to operate over a wide range. Both equipments are fed to a single 1.2-meter-long tube that serves as the laser. CGE spokesmen say the unit is able to provide laser action at more than 100 different frequencies.

Ferranti at Work on Higher-Speed Computer

Engineers at Ferranti, Limited's Automation Systems Div., Manchester, England, report they are developing a very-high-speed parallel arithmetic version of the firm's newly introduced Argus 400 microminiaturized general-purpose digital computer. In its current form, the computer, which employs Ferranti-produced microcircuits, uses serial arithmetic and ferrite core storage. The system, with a cycle time for the core store of two microseconds, is aimed primarily at process control, although Ferranti also hopes to receive some military contracts for the unit. The basic core memory of 4,096 words can be expanded in blocks to 12,288 words in direct-store address mode, and is further expandable with indirect address.

Strap-Down Gyro Testing Readied

A strapped-down inertial navigation system has been developed in-house at the Air Force Central Inertial Guidance Test Facility, Holloman AFB, N.M., to enable guidelines to be drawn up for future testing of gimballess systems. The Holloman system is designed for rocket sled testing and contains three strapped-down Kearfott King gyros. Structural features indicate that high g-loads and very high angular rates are anticipated. The facility's CDC 3600 computer is linked to the test system instead of an on-board computer.

Electrostatic Gyro Operation Continues

Some 2,500 hours of total test time have been achieved on airborne electrostatic gyros at the Air Force Central Inertial Guidance Test Facility at Holloman AFB, N.M. This includes 1,600 hours of drift testing. Longest continuous run was 37 days.

MATERIALS

Aluminum Castings To Replace Forgings

An aluminum casting alloy about 50% stronger than the most commonly used casting alloy has been developed by the Pomona Division of Electronic Specialty Co. KO1 has been tested for the Air Force by Northrop Norair. Officials there say it will "substantially replace machined plate and billets, machined forgings, and wrought assemblies in new aircraft design." Typical properties are 62,000 psi tensile, 54,000 psi yield and 8% elongation. At 500°F, KO1 shows the same mechanical properties under short-term conditions as does 356T6 aluminum at room temperature. Superiority to wrought aluminum is claimed, because loads are evenly distributed through the grain structure. Five per cent copper is used and no silicon.

Dornier Studies Destructible Stage

Dornier Systems engineers at Immenstaad, Germany, are now collaborating with a large British glass manufacturer, Jobling & Co. Ltd., to solve shaping and structural problems associated with building an all-glass unpowered second stage for sounding or weather rocket payloads. Such a vehicle, probably in combination with some form of booster destructor re-entry retardation scheme, is viewed as a possible answer to more widespread use of weather rockets from airfields for rapid gathering of meteorological data. The glass stage Dornier is studying would destroy itself at altitude by means of a steel pin actuation shattering the glass structure in a chain reaction. The intent is to eliminate or reduce all potential returning debris. U.S. firms are also active in this area, especially in studies of completely destructible rockets that would present no danger to areas on the ground surrounding the launch sites.

LIFE SUPPORT

Blood Pressure Device Has High Reliability

A blood pressure device that is showing almost 100% reliability, according to NASA, is one developed by Spacelabs Inc., and being flight-tested at the Flight Research Center, Edwards AFB, Calif., as part of an overall bioinstrumentation development program (M/R July 5, p. 28). Advancements are attributed to a specially developed Korotkow sound microphone that cancels artifact noise, use of a two-slope cuff deflation cycle, and positive, non-bypass, cuff pressure regulation.

Tests Show Difficulty of Spacesuit Movements

Qualitative data on the ability of pressure-suited subjects to perform certain movements versus their ability to do so without pressure suits has been developed at the Air Force's Aerospace Medical Research Laboratory at Wright-Patterson AFB in zero-g tests aboard aircraft. It was found that in general, suited motions required 30% more time than unsuited for both zero-g and lunar gravity conditions. Another conclusion was that all motions required 35% more time during zero-g than they did during lunar gravity.

Laser Communication Qualified Success

Tests of IBM-developed optical-frequency communications system will lead to trial of similar units on GT-7; 10-lb. transmitter contains GaAs laser

by Charles D. LaFond

WHITE SANDS MISSILE RANGE, N.M.—Following a somewhat hectic and long-delayed flight test program here, International Business Machines Corp. has completed its effort for demonstrating air-to-ground communications at optical frequencies.

A prelude to use of a similar laser system for communicating from an orbiting *Gemini* capsule to Earth next year, the tests were carried out over a five-month period using an F-100 jet aircraft.

IBM was awarded an $83,515, 12-month contract by NASA's Manned Spacecraft Center at Houston in December, 1963. Eighteen months later, and after adding another $70,000 of its own money to the pot, IBM completed the demonstration with some degree of success.

The system developed by the firm's Federal Systems Div. included three distinct subsystems—a ground laser beacon for use as a target by the transmitting operator in the aircraft, a laser voice transmitter, and a ground receiver. To assist the ground receiver in pointing toward the F-100 at all times, an AN/FPS-16 radar was employed.

● **Flight test profile**—In general, during the flight tests of the laser communicator, the F-100 was flown counter-clockwise over an elliptical course some 700 miles around the ground receiver site.

The aircraft was held to altitudes of from 10,000 to 40,000 ft. during the actual test transmission period with slant ranges from the ground receiver of from 5 to 15 miles. Relative ground speed was varied from 300 to 700 knots (2.35×10^{-2} radians/second).

From two to six passes were made during each day of flight testing, generally just before dawn.

Because of concern of possible ophthalmic damage from the ground beacon, the ground receiver test area was restricted during flight tests, site personnel were required to wear protective glasses, and the beacon was restricted to a low elevation angle limit of about 20 degrees.

In the early test flights, which ended in failure, the flight transmitter was hand held. To help stabilize the transmitter in later flights, the unit was installed in a ball-and-socket canopy mount.

● **Project objectives**—The laser communications system was developed for the Manned Spacecraft Center to determine feasibility of such techniques for use in manned orbital spacecraft.

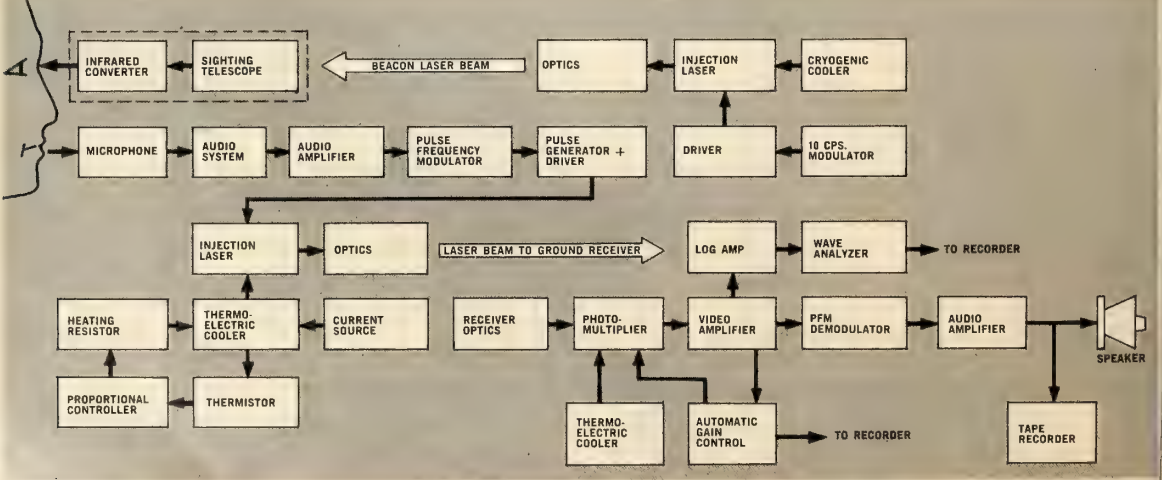
The Air Force F-100 aircraft was used under such a flight profile as to simulate a near-Earth orbital vehicle with respect to tracking angles and rates.

The air-to-ground test was designed to determine if an "astronaut" could locate a target beacon and then aim his transmitted beam with sufficient accuracy and stability to achieve a readable one-way voice transmission.

Associated test objectives included an evaluation of IR-transmitted voice signals, unfiltered pulse trains and background noise. From these recorded data, NASA scientists hope to determine some of the effects of the Earth's atmosphere on coherent optical-frequency transmissions.

● **Test results**—Late in 1964 and early in 1965 several test flights were performed with somewhat unsatisfac-

SIMPLIFIED block diagram of air-to-ground laser communications system developed for Manned Spacecraft Center.



tory results.

Noise levels, recorded at the ground station van, were excessively high and speech was unintelligible. Apparently there were no target acquisition problems.

Because the project had a very low aircraft and range priority, flights were repeatedly postponed.

Finally, two partly successful flight tests were accomplished—that is, some of the recorded communications were understandable, but of low quality.

And with that, the demonstration of laser communications from air to ground was deemed proven, at least to NASA's satisfaction, and the project was ended.

Some engineers who followed the project have indicated, however, that the only real result of the tests was a belief that the ground receiving system was acceptable, but that a more reliable aiming and stabilizing system for the flight transmitter was needed if a practical system were to evolve.

Other experts, not associated with the MSC project, have expressed continued doubt concerning the usefulness of such a test. They believe that from orbital range atmospheric influences on the beacon laser beam will make accurate aiming nearly impossible.

A planned test in *Gemini-7* (see p. 8) may provide the only answer.

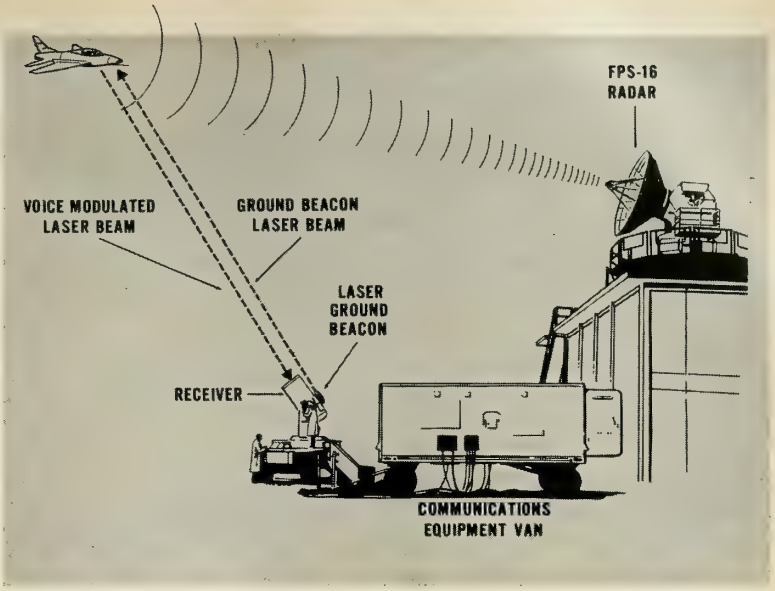
● **Receiver system**—The laser receiver and laser beacon are mounted on an old *Nike-Ajax* tracker pedestal, which was slaved to a nearby AN/FPS-16 tracking radar antenna. Total receiver weight, including counterweight, is about 100 pounds.

The beacon, a gallium-arsenide injection laser, was employed only as a flashing target for the airborne laser operator to guide on. Since his transmitted beam covered an area of only 100 ft. (10-mi. range) at the receiving end, his aim during transmissions necessarily was critical. Beacon beam spread is 10^{-3} radian.

Coherent light pulsed (one watt peak power, 5-microsecond pulses) from the beacon was in the infrared range (8,400 Angstroms). The sighting telescope in the transmitter used by the flight operator employed an image converter sensitive only to the beacon's narrow-band radiated frequency to assure target identification.

The receiver employs a 30-in.-dia. Dall-Kirkham collector. Built for IBM by the Ferson Optical Co., the folded optical collector consists of an aspheric primary reflector and a spherical secondary mirror.

During the air-to-ground transmission, received signals were passed through a multi-layer, 50-Angstrom-passband filter to clear background radiation. The filtered signal was then fed through an optical stop which limited the field-of-view to 0.001 radian.



GROUND RECEIVER/BEACON is mounted on old Nike-Ajax tracking pedestal, which was slaved to an FPS-16 tracking radar during the communications tests at White Sands.

The processed light energy was then focused on a photomultiplier (S-1 sensitive photo-cathode) for detection and amplification. To minimize noise, the amplified signal was cooled thermoelectrically and then directed into a low-noise video amplifier.

To assure that the photomultiplier noise level was compatible with the threshold-detecting gate in the demodulator section of the receiver, video amplifier noise output was fed through a bandpass filter, rectified and then used as a gain control for the photomultiplier. (During the experimental transmission, photomultiplier gain variations were recorded to provide a measure of the changes in received background radiation.)

A single-shot multivibrator was next employed to produce an output train of standard-area pulses whose repetition rate was based on that of the video-pulse input. A low-pass filter provided demodulation and the processed signal was amplified and fed into a speaker.

The receiver was provided with a shutter arrangement at the collector end for protection against accidental exposure to direct solar radiation. Operated automatically by a solar-cell sensor assembly, co-linear with the telescope axis, it opened only when the solar radiation level was reduced to safe limits.

● **Transmitter system**—Measuring 10 x 5 x 2⅝ in., the 10-lb. portable IBM laser transmitter provided a sighting telescope for the operator and contained a gallium-arsenide injection laser, associated modulation and control electronics, plus a nickel-cadmium battery pack. Average transmitter power was ¼ watt with a 5-w peak power.

The operator trained his laser beam on the ground receiver during transmission by sighting on the flashing ground laser beacon through his telescope. The target beam showed up as a visible spot on a reticle within the scope that was boresighted with the transmitter laser beam.

To transmit, the operator spoke into a microphone built into the transmitter. The transduced audio signal was amplified in two stages providing a 35-db voltage gain and a 15-db amplitude compression. Frequency response in the audio section was from 0.3 to 3 kc.

The amplified signal was then directed to a pulse-frequency modulator—a four-layer diode operated as a frequency relaxation oscillator. The audio input signal level was high enough to swing the pulse repetition frequency (PRF) of the modulator from 70 to 130% of any quiescent point between 4 and 20 kc.

The modulator output was a pulse train fed into the injection laser driver—a delay line and an avalance-transistor switch. The latter, when triggered by the modulator output, discharged the delay line through a pulse transformer, thus energizing the laser.

A thermoelectric cooler was used to hold the GaAs laser at 16°C. Laser output at that temperature is at a wavelength of 8,900 Angstroms. The infrared beam was directed into the optical section where it was reflected 90 degrees and then passed through a 7-cm focal-length lens. The resulting beam had a spread of only 0.002 radian. ■

Early Start on Mars Systems Urged

Hamilton Standard study for NASA says existing concepts are adequate; CO_2 reduction considered most critical area

by Heather M. David

WINDSOR LOCKS, CONN.—No major breakthroughs or new concepts in life support will be needed for manned exploration of Mars as early as 1973, says Hamilton Standard Division of United Aircraft Corp.

However, according to a study conducted by the division under NASA sponsorship, much research, design and development must be done to perfect the existing concepts. Since the lead time is long—for a "crash" program three or four years, for a more measured program seven or eight years—work should begin in the near future, Hamilton Standard engineers recommend.

Their nine-month study indicated that the most critical area is advanced design and development work on reduction of carbon dioxide for reclamation of oxygen, and subcritical cryogenic storage of oxygen and nitrogen. Study criteria assumed a six-man voyage to Mars sometime after 1973, with a 120-day Earth-to-Mars time, a 40-day stay on Mars, and a 260-day return trip—for a total of 420 days.

The spacecraft would have three modules, a Mission Module, Excursion Module, and Earth Re-entry Module. Power would be supplied by a nuclear reactor on the main vehicle and fuel cells on the Mars Excursion and Earth Re-entry Modules.

In the NASA-postulated mission design, the crew of six would travel from Earth to Earth orbit in a ferry vehicle such as a modified Apollo or even the Re-entry Module. In orbit, they would transfer to the Mission Module for the Earth to Mars orbit. Three of the crew would then descend to the Martian surface in the Excursion Module and stay for 40 days, then transfer to the Mission Module for the return trip. Before re-entry, they would transfer to the Earth Re-entry Module.

Regenerative systems will be requisite, except for the Earth Re-entry Module. The engineers estimate that if stored oxygen were to be used, as in *Gemini* and *Apollo*, it would require nearly 5,000 lbs. of oxygen, compared with about 800 lbs. for reclamation equipment to recover oxygen from CO_2. Carbon dioxide removal equipment, if the lithium hydroxide systems were to be adapted and extended for the longer missions, would require 6,200 lbs. of lithium hydroxide. A regenerable adsorbent, on the other hand, would weigh about 250 lbs.

The same principle applies for water, both for personal consumption and for cooling. Crew drinking water, if not reclaimed, would weigh 50,000 lbs., Hamilton Standard estimates, while the equipment to reclaim it from urine and wash water would amount to about 250 lbs. And while water is used as a heat sink for present manned spacecraft, extension of such use to the Mars mission would require over 300,000 lbs., compared with a 100-lb. space radiator.

● **CO_2 removal and transfer**—The most promising method of CO_2 removal, Hamilton Standard engineers say, is by regenerable solid or liquid absorbent. The solid absorbent, or zeolite molecular sieve, has been extensively developed and has been run for periods as long as 50 days without deterioration of the chemical. Use requires a moisture bed upstream of the zeolite to prevent water contamination. This approach receives top recommendation for the Mission Module and alternate recommendation for the Excursion Module.

Alternate approach for the Mission Module would be a liquid absorption method, utilizing a chemical reaction that can be reversed by heat. However, while this system has been used in submarine work, no development work has been done to adapt it to zero-gravity conditions.

The most desirable CO_2 removal system for the Excursion Module is cryogenic freeze-out, Hamilton Standard says. Pre-dried air bearing carbon dioxide would be processed through a freeze-out heat exchanger in which the CO_2 would be collected. This is particularly suited to the Excursion Module, the engineers say, since the cryogenic fuels supplied for the fuel cell and spacecraft atmosphere would make available enough for this use.

● **Carbon dioxide reduction**—Neither the Excursion Module nor the Earth Re-entry Module require reduction of carbon dioxide to oxygen, Hamilton Standard says. Both would more economically carry cryogenically stored oxygen.

For the Mission Module, however, it is an absolute necessity. Parallel development work of two methods should be undertaken until a choice can be made, HS recommends. These are electrolysis of CO_2 across a solid electrolyte, and electrolysis of molten carbonate.

Regarding the solid electrolyte system, the research group recommended electrode studies to increase the useful life of electrodes, and a study of catalytic reactor design to increase the carbon-to-catalyst ratio.

In the molten carbonate method—which has potential of greatest weight savings, the engineers say—experimental work needs to be done on improving carbonate density and removal techniques and to convert present laboratory concept into a flight prototype design.

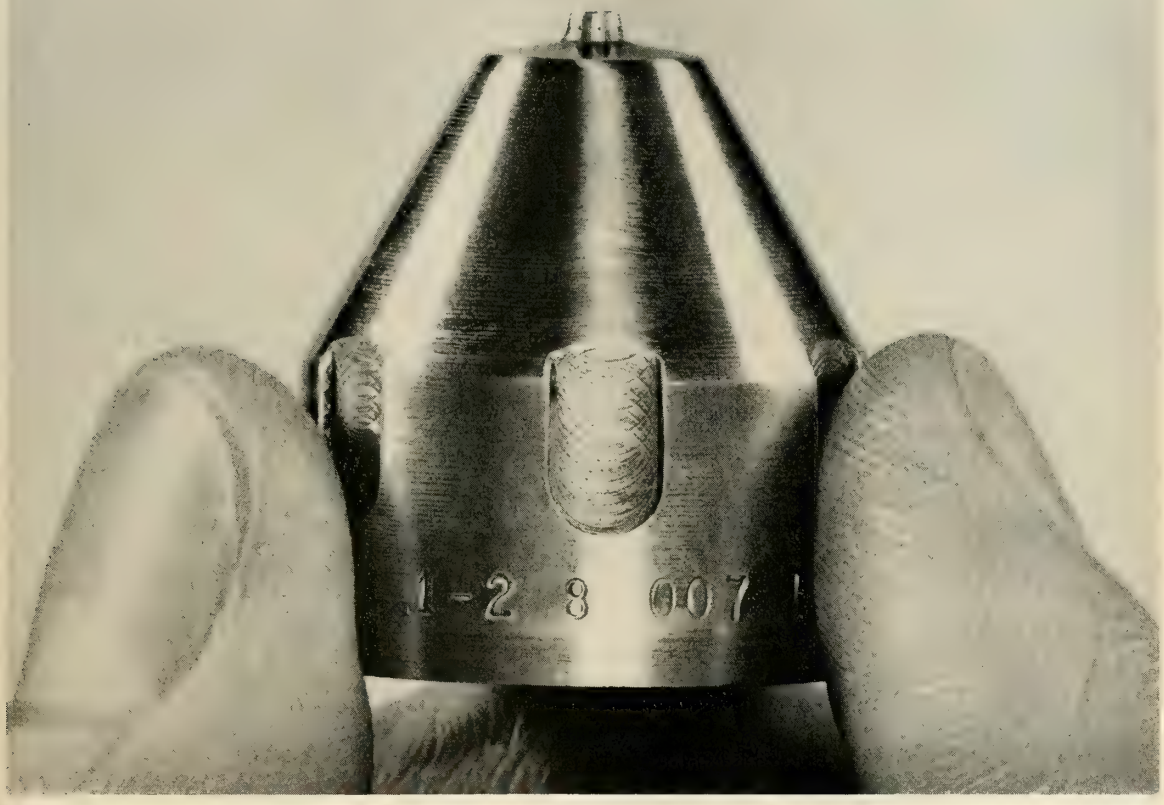
Although the Bosch reaction (hydrogenation) system was considered promising, it was dropped because of complexity and weight of equipment. Also considered, but not recommended, was the Sabatier process (hydrogen reduction), with even greater weight penalty and the problem of dumping methane.

● **Water reclamation**—Three approaches are promising for reclaiming water from urine and wash water, but all have problem areas requiring additional work in spite of the fact that they are in the breadboard stage.

In the air evaporation method, the prime candidate, work is needed to develop methods of regenerating the wicks, and to develop open loop operation with particular attention to possible contaminant problems.

Work on electrodialysis is recommended, to develop means of increasing membrane life and research means of regenerating charcoal. In vapor compression, a method is needed to effectively remove scale from the evaporator and improve the start cycle to make the unit more acceptable to part-time operation. HS also recommends development of better detergents and methods of removing them after use. ■

Cleaning these microscopic spray holes of fuel injector cups was a critical problem at Cummins.



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Needle-Nosed Mars Probe Suggested

Goddard scientists think vehicle would allow sufficient payload to gather abundant data in time to be of use in Voyager design

by William S. Beller

SCIENTISTS at a NASA center are proposing a needle-nosed probe they hope will be launched from a fly-by vehicle into the Martian atmosphere, picking up pressure, density and mass data until it crashes into the planet.

Spokesmen at Goddard Space Flight Center, Greenbelt, Md., where preliminary design is under way, hope the probe will be used in the 1969 *Voyager* tests. The *Voyager* program calls for a soft landing on Mars in 1971 to collect data about the planet's surface, particularly biological. The program is directed by the Jet Propulsion Laboratory.

The needle-nosed probe would weigh only 60 lbs., would be 48 in. long and would be a "considerate" passenger because it would not call upon the fly-by vehicle for any help except transportation to the vicinity of the planet. "No special trajectories would have to be flown, or maneuvers made," George M. Levin, who conceived the probe, told MISSILES AND ROCKETS. He is on the staff of Goddard's Advanced Missions Analysis Group.

● **Mars entry probes**—Other NASA centers are also designing Mars probes. Ames has a spherical one and Langley is working on a soft lander. None have been picked for the mission because 1) it is not known whether the *Voyager* test flight of 1969 will be directed toward Mars, and 2) NASA headquarters is not entirely convinced such a probe is needed, particularly since *Mariner IV* is expected to gather Martian atmospheric data with its occultation experiment.

Nobody is arguing that knowledge of the properties of Mars, such as surface pressure, is not needed in order to get the most out of the *Voyager* flights. A difference of only 10 millibars in estimating the surface pressure could cut about two-thirds off the landed payload.

This point was dramatically brought out in an Avco Corp., Research and Advanced Development (Avco/RAD) division study last year. It was shown that if the surface pressure on Mars were as low as 10 mb (pressure at approximately 100,000 ft. above the Earth), then a 500-lb., 90-in.-dia. modified *Apollo* configuration could soft-land about 125 lbs.; of this, only 8 lbs. would be scientific instrumentation. On the other hand, for a 20 mb surface pressure, almost 400 lbs. could be landed, with a significant increase in the weight of the landed instrumentation, estimated by Levin at more than 100 lbs.

Unfortunately, knowledge of the Mars atmosphere is not very good, and the improvement, even with the *Mariner IV* data, is not expected to be sufficient for a precise design of the *Voyager* lander, according to some scientific observers.

● **Pressure data changes**—Two years ago it was believed that the Mars surface pressure was 85 mb, a figure derived from ground-based polarimetric measurements. Subsequent spectroscopic observations showed the surface pressure was perhaps between 10 and 25 mb, a decided improvement, but still one that could lead to over-designing *Voyager*. Through its occultation experiment, if it works, *Mariner IV* may be able to measure the pressure within 25% of its actual value.

"That's good enough for scientific use," said Levin, "but not for engineering designing."

In this *Mariner IV* experiment, the spacecraft is expected to fly behind the planet. As it occults the limb of Mars, the spacecraft's 2,300-mc tracking and telemetry signal will be refracted and defracted by the Martian atmosphere before arriving at Earth receiving stations. A measure of this defraction is a measure of the scale height of the atmosphere. It is hoped that these measurements can be made right down to the surface, and that from them the surface pressure can be derived.

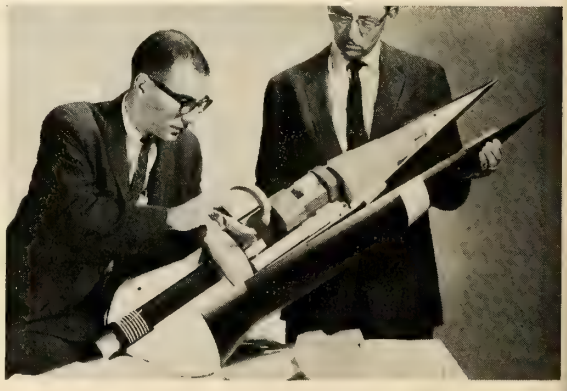
W. G. Stroud, chief of Goddard's Advanced Missions Analysis Group, seconded Levin's opinion. He noted that the needle-nosed probe would tell the surface pressure within an accuracy of about three percent, which is what is needed for *Voyager*. He affirmed that only by going into the Mars atmosphere "with the needle-nosed probe, or some blunt body, can we really get the data we need." He said he is "absolutely convinced of this . . . and I think quite a few of the scientific people are also convinced of it."

Even if a probe does gather data about the Mars atmosphere in 1969, there is doubt it will be able to do more than furnish a "no" answer, or allow for some quick fixes, if they are necessary. Still, without these data, "we would be taking a big chance," Stroud said. He maintained the probe should be sent in the 1966-67 Mars opportunity, but he didn't hold out much hope for this.

He explained that it takes about four years to feed the probe data into the *Voyager* system. "If we fly in '69, then we don't get the data back until almost eight months because of the flight time. By the time the data get reduced, the rest of that year is gone. And then that leaves only one year—the year between 1970 and the 1971 opportunity —to try to get the data engineered into the system. That's just too short a time."

The needle-nosed probe system uses a sharp nose, low-drag body designed to eliminate the plasma interference with

GEORGE M. LEVIN (left) holds static pressure ring of needle-nosed probe model. Builder Mark Hanchette is at right.



communications during entry into the Mars atmosphere. Experiments in the Earth's atmosphere show this idea is sound.

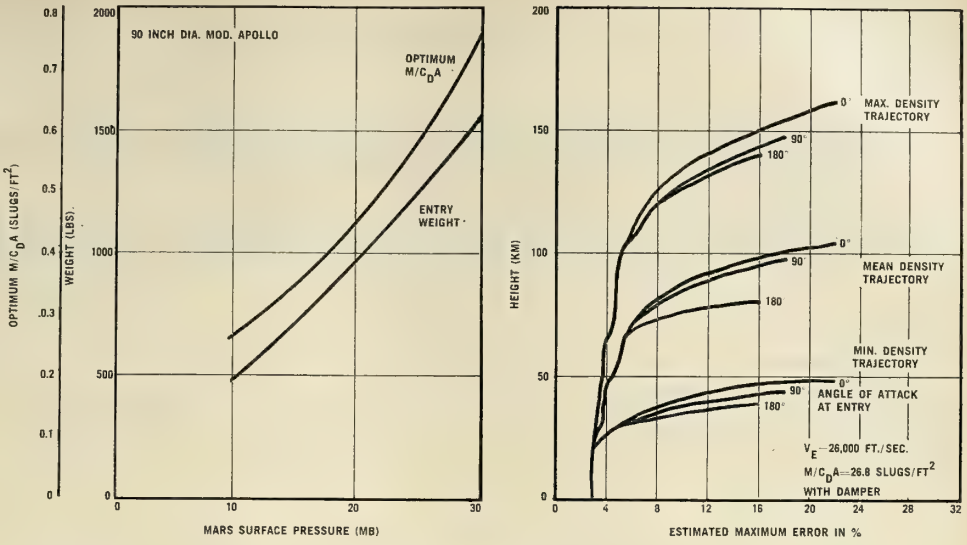
● **Experiments**—Four sets of measurements would be made during entry, and telemetered to the fly-by spacecraft:

—Dynamic pressure to provide an ambient density profile;

—Static pressure for an ambient pressure profile;

—Deceleration for an independent measure of density.

—Ambient atmospheric composition using a mass spectrometer.



LEFT: Maximum entry weight into Mars atmosphere for soft lander. RIGHT: Estimated maximum error in density derived from impact pressure. (M = probe mass, C_D = drag coefficient, A = probe cross-sectional area.)

Redundancy is the most important characteristic of the pressure and density experiments for the needle-nosed probe. John Ainsworth, Goddard's project scientist for the probe, designed the instrumentation system so that if the pressure subsystem went out, for instance, another functioning subsystem would give data from which pressure could be derived.

These experiments are actually an extrapolation of a standard technique used in rocket work for sounding the upper atmosphere of Earth. Similar instruments and gauges would be used on the Mars probe, except for the mass spectrometer.

The problem of extrapolation arises because entry into the Mars atmosphere will be at considerably higher speed than sounding rocket flights into the Earth's atmosphere. The Mars entry is estimated at Mach 20-45; a ballistic missile re-enters at about Mach 26. Nevertheless, Levin is confident there is sufficient Earth entry experience at high Mach numbers "to remove any doubt as to the ability to design a vehicle which will communicate continuously throughout the required measurement interval and which will have sufficient stability to permit efficient use of the measurement instruments."

The mass spectrometer, built jointly by the physics branch of Goddard's Aeronomy and Meteorology Div. and Consolidated Systems Corp., was specifically designed for planetary exploration. A prototype is working now. The instrument has a very rapid response and is designed to scan mass 10 through mass 50 every second. It weighs about 6 lbs. and occupies about 226 cu. in. Its major attribute, besides the distinctly scientific one, is that it will be able to withstand sterilization.

● **Double redundancy**—The needle-nose probe experiment itself could be made redundant by carrying two of the probes and using the second as an affirmation of the first, or for extended scientific use to sound different locations on the planet.

In any event, separation from a fly-by spacecraft would occur about 20 days before a probe's entry into the Martian atmosphere. The probe would be separated by a recoilless cannon so that no momentum is transferred to the spacecraft. In this way, the path of the spacecraft would not change.

Once the probe entered the Mars upper atmosphere, a "g" switch would put the instruments and telemetry into operation. At about the same time, aerodynamic forces would begin stabilizing the probe, turning it nose down toward Mars in an oscillatory mode. At about 70 km above the planet's surface, for a 25-mb surface pressure, the probe is expected to be sufficiently damped to make pressure measurements meaningful.

The total time from "g" switch "on" to impact is expected to be less than 40 seconds. At a sending rate of 1,344 bits/second, the total data storage requirement for the fly-by spacecraft will not be more than 55,000 bits.

Stroud does not see the probe experiment as a costly one, except for the initial development work. "We do want to fly it probably as a piggy-back on one or more of the ballistic missiles," he said. "And this Earth-entry test program, which is necessary and planned for the (Ames) sphere, is what would make the development program somewhat more expensive than a normal re-entry experiment." He explained that the entry tests would provide calibrations by means of a known atmosphere, and from these, the unknown could be measured.

Ainsworth has conducted an extensive study on the use of the Goddard needle-nose probe and the Ames sphere for sounding the atmosphere of Mars. He concludes that the optimum use of the spherical Mars probe is for measuring the upper atmosphere of Mars while the needle-nosed probe is for measuring the lower.

From this work, it is surmised that the optimum initial exploration of the Mars atmosphere could be effected by using both systems on the same fly-by pass.

A contract has been let to General Electric Missile and Space Div., Valley Forge, Pa., for a study of the effects of ionization, dissociation, and ablation products on the measurements made by the mass spectrometer. A second study contract has been given to TRW, Inc., for preliminary design of a mechanically passive damping system for subduing entry oscillations.

Ames Research Center is carrying out an extensive ballistic range test program on the needle-nosed configuration, while Goddard is assisting Ames in the design of the communications system for the spherical probe. Thus, while the two centers are each competing to achieve the better vehicle they are also cooperating to get the best. ■

Athena Impact Accuracies Point To Possibility of Longer Unguided Flights

by Rex Pay

WHITE SANDS MISSILE RANGE, N.M.—Pre-launch impact prediction for the 450-mile overland flights of the *Athena* re-entry test vehicle is working so well that unguided rockets can now be fired over even longer ranges.

Athena is a four-stage vehicle in which the first two stages are unguided and the last two are command-guided. Atlantic Research Corp. is prime contractor.

"I feel we can fire unguided rockets over thousands of miles," said Henry Rachele, who developed the mathematical techniques basic to the *Athena* impact prediction system. Rachele is chief of the Meteorology Research Division of the U.S. Army Electronics Research and Development Activity here.

Their lower cost and the fact that they do not consume payload weight are the chief advantages cited for unguided rockets. In programs like *Athena*, involving a large number of firings, the cost savings are significant.

Main problem in unguided rockets is to correct for wind thrust during the early launch phase. A uniform wind of 1 mph at the *Athena* launch site at Green River, Utah, gives a 7-mile displacement of the *Athena* impact point at White Sands.

However, allowable dispersion in impact due to wind effects in the *Athena's* flight is less than the dispersion allowed for all other errors. Rachele says there have not yet been enough *Athena* firings to give a good number on the dispersions attributable to the various error sources. Some shots have impacted within 5 miles of the target area and others have had to be destroyed.

Impact error of unguided rockets is still measured in miles rather than yards, but the *Athena* shots are proving that wind errors can be controlled sufficiently for many rocket experiments.

In recognition of the potentiality of the impact-prediction techniques now developed, a national meeting on unguided rocket ballistics is planned at White Sands in January, 1966.

● **Complexities**—Problems of wind measurement and non-guided rocket impact prediction have been worked on at WSMR for several years. Recent increases in range and altitude, coupled with the use of short launchers, have multiplied measurement and computation difficulties.

WSMR is about 40 miles wide at the *Athena* impact area, and a correction capability for wind effects of up to 150 miles has been built into the system. Flight safety requirements, however, have set the correction to a limit of 80 miles. Rachele says it is not uncommon for a correction of 60-70 miles to be made in second-stage impact.

Main elements of the impact prediction system are a complex wind measurement operation at Green River, a data link from there to an IBM 7094 digital computer at WSMR, and an analog computer (the Automatic Rocket Impact Predictor—ARIP) at Green River.

ATHENA ROCKET on launcher.

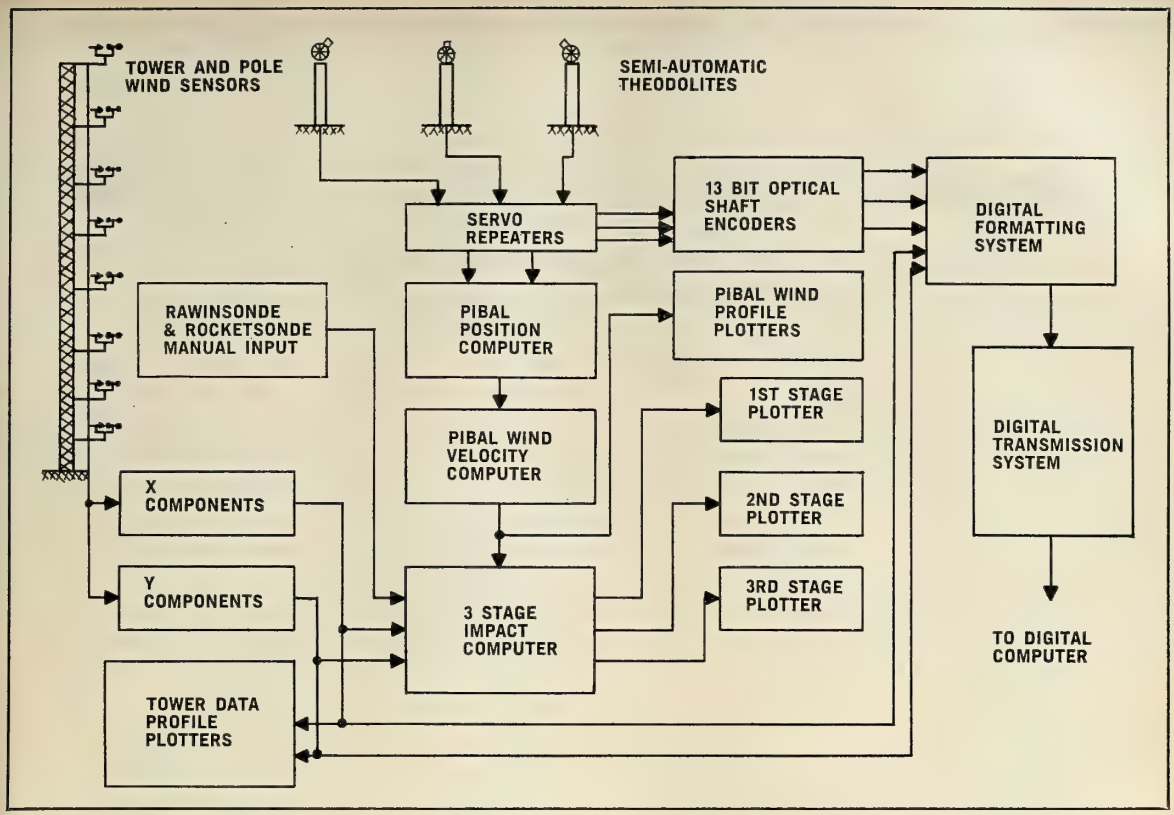
Located in the Green River blockhouse, ARIP computes impact points for each stage, using a simplified ballistic model. This provides a guideline on results from the 7094, which takes about five minutes to carry out a detailed computation of the ballistics of the *Athena* under telemetered wind conditions. ARIP also supplies continuous estimates of the variability of the impact points at the end of countdown. A meteorological officer interprets the estimates in relation to wind conditions at the Green River site.

● **Wind effects**—*Athena's* initial aiming is decided by the angle at which its launcher is pointed. In flight it is finstabilized and spinning. The fins make it particularly sensitive to winds, crosswinds causing twice the deviation of inline winds. During rocket burning the booster tends to weather-cock; after burnout it tends to turn the opposite way.

With a uniform wind, the first 10,000 ft. of altitude give 80% of the wind effect. By 100,000 ft., 98% of the wind effect has been experienced. However, a peculiar wind structure developed last fall, with the result that most of the effect was felt above 100,000 ft., and it became apparent that wind measurements up to 200,000 ft. are essential.

Until a year ago there were no wind soundings at Green River above 100,000 ft. The *Athena* program has now revealed how strong winds at altitude can be when surface winds are mild—winds of 150-200 knots have been measured above 100,000 ft.

There are three launch pads at Green River. Near each is a 90- or 125-ft. pole with wind sensors at two levels. A single 500-ft. tower supplies wind readings at six levels for all three sites. A small pilot balloon is tracked by semi-automatic theodolites to provide wind readings from 500 to 10,000 ft. The wind sensors and theodolites transmit



PREDICTED IMPACT points are mapped on x-y plotboards from a special-purpose analog computer output. Precision impact calculations are carried out on a digital computer 450 mi. away and returned to block-house by Electrowriter.

the analog data directly to the ARIP.

From 10,000 to 100,000-ft. wind readings are obtained from a GMD-1B standard upper-level balloon system which provides pressure, temperature, and humidity data directly and wind data indirectly. This information is reduced manually and communicated by telephone.

Above 100,000 ft. winds are measured by radar detection of chaff distributed by *Loki* rockets. At present an MPQ-12 radar is used for balloon tracking, but there are plans to use an FPS-16 radar with automatic readout to the computer, to track both chaff and balloons with high precision.

Two main functions of the ARIP computer are to display calculated wind profiles in three-component form and wind effect up to and through lift-off, and to give a means of estimating dispersion attributable to wind variability.

A continuous display shows pole and tower wind information as component 10-second mean profiles, updated every minute from the surface to 500 ft. To provide a check on local wind variations, the bottom wind sensor on the tower is at the same level as the top pole sensors. Modified Beckman and Whitley wind-measuring systems are used.

A 5 ft.-per-sec. wind error has been allowed for in the system specifications. "In terms of the manufacturer's specifications we feel we are well within this accuracy," said Rachele, "but in the field the situation may at times be marginal." Errors in field measurement are largely due to wind-shadowing by the tower, vertical wind components, and induced balloon motion. The division is investigating these effects.

● **Presentation**—A display of component winds from 500 ft. to 10,000 ft. is produced as the information becomes available from the balloon trackers.

Computation within ARIP produces the wind components from azimuth and elevation angles from any two of the three pilot balloon trackers. Ballistic weighting factors and unit wind effects, pole and tower winds are added to the pilot balloon data to determine the wind effect on as many as three rocket stages.

Wind effects above 10,000 ft. are estimated manually at the balloon-tracking and radar sites some time prior to the launch, and put into the ARIP as a bias. The ARIP then continuously plots the impact points for the stages on x-y plotters, superimposing the impact points on range maps.

All tower, pole and pilot balloon data from the semiautomatic theodolites are converted into digital form for transmission from Green River to the computer center at WSMR. Sensors are sampled at the rate of one data point per second. Conversion from analog to digital format is carried out by a Collins Kineplex TE-210D-2. This is capable of a 2,400-bits-per-second data rate over a voice bandwidth channel such as a wire line or microwave circuit. Theodolite data are transmitted in 13 bits, wind instrument data in 11 bits.

Data sent back to the computer center are used in a set of five equations of motion, involving very few approximations. These give the three-dimensional position and the attitude of the rocket as a function of time, and are solved on the 7094 by a numerical integration technique. Computation takes about five minutes.

Results of the digital computation are transmitted back to the block house at Green River in written form by means of a Victor Electrowriter system, to avoid speech ambiguities.

If ARIP is not functioning, except for the digitizer, or if there is a failure on the wind tower, the balloon data from the surface to 10,000 ft. can be used for the digital computer ballistic model. This may allow a firing if conditions are not extreme. ■

Interest Grows in Stabilized Skylark

Three-axis technique on British rocket stirs enthusiasm abroad; Elliott-Automation pushes program to add further capabilities

by Michael Getler

FRIMLEY, ENGLAND—A program to expand the scientific data-gathering capabilities of the already versatile fully stabilized version of the *Skylark* rocket is under way at the Space and Guided Weapons Division of Elliott-Automation Ltd. here.

It calls for a continuing round of improvements in the pointing accuracy of the current solar-oriented *Skylark*, the addition by mid-1966 of a system capable of aiming experiments at either the Sun or the Moon with even greater reduction of pointing errors, and the study of a star-pointing system which could become available in 1967.

Skylark, a flexibly designed sounding rocket that lofts payloads of 150-200 lbs. to altitudes of 100-120 mi., has been successfully fired more than 100 times from the Woomera, Australia, range in its original configuration—one involving a basically unstabilized payload-carrying section.

Development of a three-axis stabilization system began at Elliott in 1962. Intent was to provide experimenters with a platform oriented to the Sun and stabilized about all axes for the five or six minutes between the rocket's ascent beyond atmospheric absorption layers and its re-entry into the atmosphere.

The first three vehicles carrying the new stabilization system were launched late last year. The high-quality data and photographs gleaned from these flights have created enthusiasm for the technique on both sides of the Atlantic. First detailed results were reported at the recent COSPAR meeting in Argentina (M/R, May 24, p. 16).

The *Skylark* airframe is manufactured by British Aircraft Corp. and the design authority and integration agent for the program is the Royal Aircraft Establishment at Farnborough.

● **One of a kind**—The most extraordinary thing about the *Skylark* stabilization system is not its design technology, but the fact that it exists. It is the only fully stabilized sounding rocket of its type.While the technology to build such systems, which have a considerable appeal to experimenters with limited budgets and long-exposure cameras, is well within the state of the art, development of an operational system has not been pursued vigorously elsewhere.

STABILIZED SKYLARK undergoes alignment for experiment at Woomera Range.

There are some mitigating factors, however. For one, U.S. scientists, in particular, have expressed interest in systems able to point at bodies other than the Sun. This is one of the factors behind Elliott's efforts to expand its system's capabilites. Another is that many experiments can be, and have been, conducted with just two-axis stabilization, using a de-spin type of mechanism when needed for optics to offset vehicle roll instabilities.

However, Elliott engineers stress that much less photographic smear and data-point jitter is produced with the fully stabilized system. The spectrographic data and solar X-ray photographs shown at the COSPAR meeting were described as perhaps the most detailed ever obtained. The photographic possibilities of such a system are emphasized by engineers here as having perhaps the greatest appeal, especially when observatory-type experimenters can get back their data in the format to which they are accustomed.

The *Skylark* ACU actually stabilizes not only the forward (3-ft.) payload area, but the total 12-ft.-long section of the rocket after motor separation. This can provide additional payload volume; it has already allowed some flexibility in altering equipment locations to improve pointing accuracies.

● **Sequencing**—Separation of the boost engine actually initiates the ACU sequencing. The engine attachment ring also lifts off the airframe the four so-called "eyelids" which provide a cover for the solar sensors throughout the

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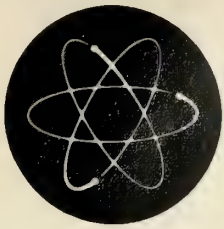

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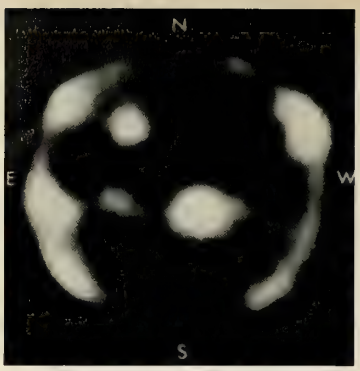

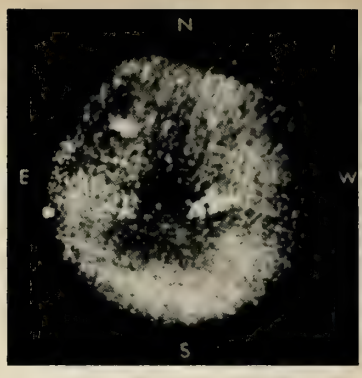

LEFT: Photo taken from stabilized Skylark flown on Dec. 17, 1964, is believed to be best solar X-ray photo ever obtained by any means. RIGHT: Photo made by ground observatory in India at about same time Skylark was 100 miles above Woomera. Built up by a scanning method, it shows Sun as viewed by ultraviolet light from ionized calcium. Bright spots on both photos indicate coincidence of hot-spot activity as viewed from Earth and soft X-ray emission measured from space.

launch environment. Each of the four assemblies contains two coarse sensors for solar acquisition and a fine sensor with a ±10-degree field of view.

The silicon solar detectors act in conjunction with rate gyros to provide signals to torque motors which drive poppet valves controlling the release of the nitrogen control gas stored at 3,000 psi. There are four control jets associated with alignment of the vehicle in the lateral axes.

Roll alignment is achieved through another two pairs of valves and jets activated by combined output of the rate gyros and an on-board two-axis magnetometer which uses the magnetic field vector as a reference axis.

The ACU gas system is described as a single, full-thrust system providing 1 lb. of thrust in the lateral axes and 5 lbs. in the roll direction. The poppet valves, which required an extensive development effort to develop low leakage rates, are able to release minimum pulses of 2 millisecs effective duration.

The gas vessel carries 5 lbs. of nitrogen. Engineers here say that about half of this would be used up in initial acquisition under the worst case situation. The ACU in its current version is designed to cope with vehicle rates at initiation of control of up to 60 deg/sec. in the lateral axes and 300 deg/sec. in the roll axis in less than 30 seconds.

• **Improvements**—Pointing accuracies of the system demonstrated during the first three stabilized flights were appreciably better, according to Elliott, than those required. Experimenters report achieving pointing bias errors of less than 10 arc minutes and pointing noise errors of less than 1.5 arc min. RMS. One experimenter, using a spectrometer with a secondary mirror, reported image accuracy within a few arc seconds.

Performance of the first three flights, and minor refinements in the electronics made since then, have led Elliott engineers to claim that the four remaining *Skylarks* of the current model, which probably will be fired between August and December, will provide pointing bias in the lateral axes of less than 10 arc minutes from the Sun center, and of less than 5 degs in the roll axis when the magnetic field is orthogonal to the Sun line.

The roll accuracy is reduced when the angle between the magnetic field and the Sun line increases appreciably. In the lateral planes, pointing noise limit cycle can be set to 10 arc secs. RMS, according to Elliott, and the roll limit cycle can be set to 1 deg RMS with the proper magnetic field/Sun alignment.

The first units of the second-generation Sun- or Moon-pointing ACU's are now nearing completion, and tests are slated to begin this month. First flight is expected in about one year. The sensors for this vehicle will be provided by RAE-Farnborough, not Ball Bros. of Colorado, which has produced them until now. The U.S. company, one observer here says, may have refined itself out of a job. Engineers here reportedly had trouble fitting a continually improved sensor into a production design.

There are also other important changes in these units.

The pointing bias will be further reduced by moving the Sun/Moon fine sensors further forward, locating them on the experiment portion of the stabilized section and away from the aft section to cut down on any misalignment due to mechanical bending. Pointing noise also has been lowered through introduction of a more refined thrust pulse modulator using proportional control.

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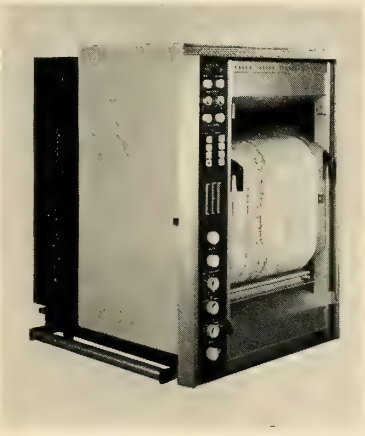

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Also, Elliott has designed a new deployable structure for the magnetometer which will carry it 5 ft. aft of the vehicle, attached by a "jack-in-the-box" type extension strut, and away from any interfering magnetics on the vehicle. Tests have shown this device to be highly repeatable.

The roll thrust levels will also be cut to 1 lb. in the next version. Engineers here claim the performance in roll on the first three flights was almost too fast. Also, the poppet valves will be located in a separate container at 250 psi, not in the 3,000-psi environment of the nitrogen vessel as in the earlier version. This should also make it possible to run the main gas reservoir to lower levels.

● **Targets**—These are the acquisition and pointing figures Elliott claims will be available with the new ACU: the unit should cope with initial vehicle rates of up to 50 deg/sec. in lateral axes and 100 deg/sec. in roll, with less than a 30-sec. acquisition time. Pointing bias for the Sun in the lateral axes should be less than 30 arc secs.; for the full Moon—less than 6 arc min.; and for the half Moon—less than 15 arc min. Roll bias of 1 deg is expected with the magnetic field orthogonal to Sun or Moon line. Pointing noise in the lateral axes is stated as 1 arc sec. RMS for the Sun and 5 arc secs. RMS for the Moon. Roll noise is 20 arc secs. RMS for both.

Study of a third-generation vehicle with a stellar pointing capability is expected to be completed in about six months. There has not yet been a decision to proceed with this program. Time of availability will depend in large part on the selection of the star tracker, an area which is not widely developed in the UK, and which UK scientists feel is too expensively developed in the U.S. This vehicle could use integrated circuits to fabricate the 24 dc amplifiers in the ACU.

In a related area, Elliott is also working under RAE contract at development of a satellite attitude stabilization system in which the stabilization loop is similar to that used in *Skylark*. The prototype will be tested aboard *Skylark* in free fall later this year. The satellite system uses liquid propane rather than gaseous nitrogen. The system could be of potential use in any future UK military satellites.

The firm has also advanced an attitude system using flywheels and magnetic torquers for an ESRO-initiated study of a large astronomical satellite. Elliott is teamed with BAC as the UK entry in the competition with French and German teams. Studies have been submitted and there is some hope that a satellite specification may be forthcoming in July. ■

Rocket Recovery System Nears Flight

Germany's paraglider-ground control system will get first work-out this fall in flights from Sardinia

IMMENSTAAD, GERMANY—The West German government-sponsored program to develop a completely recoverable research rocket—including both the booster portion and the payload—will move into its initial, and most critical, flight test phase this fall.

These first flights, coming about one year behind the original schedule, will be made from the Italian Test Range in Sardinia, probably in October or November. They will include only full-scale unpowered gliding models of the rocket, dropped from helicopters at altitudes of 3,000 ft. to three miles.

These drop tests, however, are most important to continuation of the entire project, since they will provide the first real clues regarding the aerodynamic performance of the rocket's Rogallo-wing type of recovery system and the ability of the ground-control loop operators to maintain recovery control within a 3-mi.-dia. circular landing pattern and a 3,000-ft. touchdown area.

If these systems prove to be workable, fabrication of the single, liquid propulsion booster stage will begin. Project engineers speculate that a complete, ground-launched, powered system could be operational by 1968.

● **Highly marketable**—Successful development of the vehicle, being carried on under Germany's 621 project by engineers here at Dornier Systems GmbH, could mean considerable business potential for the associated German manufacturers.

Project engineers here feel strongly that a completely recoverable and reusable vehicle such as the one in development would have wide appeal, particularly in Europe, for a number of tasks and for a number of limited-area launch sites.

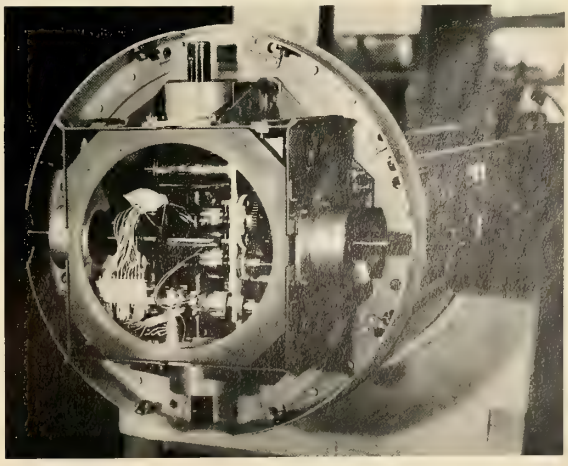
Dornier studies, made to optimize payload capabilities, indicate that demand for a vehicle able to loft 5 kg to a 48-mi. altitude should fall between 50-100 launches annually for research experiments, and between 300-400 for meteorological purposes.

Dornier estimates that the cost of the complete system, including the ground control station, when used by an agency in a continuous program would be roughly $1,500-1,750 per firing. These figures are based upon use of comparatively inexpensive liquid fuel, such as the currently planned tetramine and red-fuming nitric acid mixture. Engineers also point out that there will be different numbers relating to reuseability for various systems. The on-board electronics, for example, should be reuseable for 30-40 flights, and the fins and main airframe for about 4-5.

● **Background**—Work on the 621 project got started at Dornier in 1962. Other major contractors on the program include Telefunken AG, responsible for the ground tracking and command system and on-board telemetry transmitter, and Standard Elektrik Lorenz AG, which will provide the 18-channel on-board digital PCM telemetry equipment and multiplexer. The SEL package will use Texas Instrument Co.'s integrated circuits and will mark the first actual use of digital PCM equipment in any

(Continued on page 39)

LEFT: Gliding model of 621 paraglider (without booster) undergoes calibration tests in wind tunnel at Dornier Systems. Glider is inverted in the tunnel. Probe extending from nose cone aids air vector alignment. First helicopter drop tests are expected this fall. RIGHT: Electronics associated with rocket's rudder and elevator control system.



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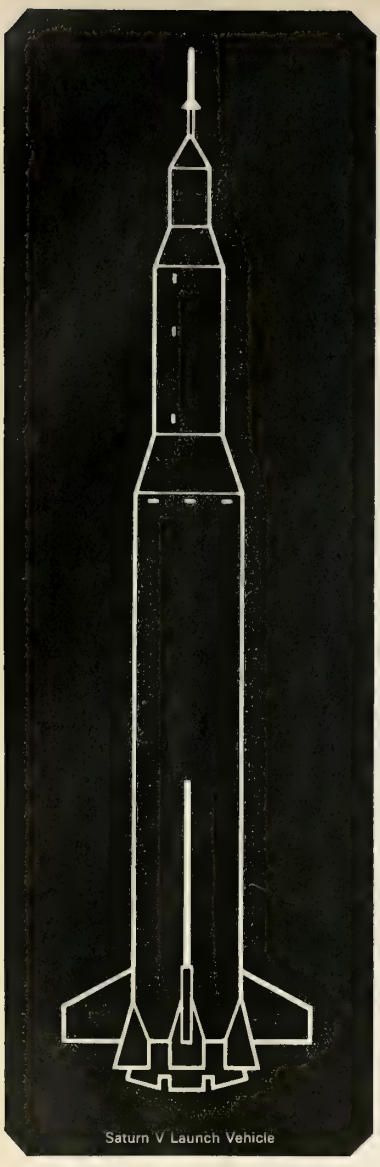
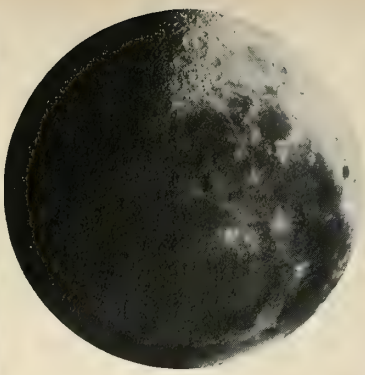
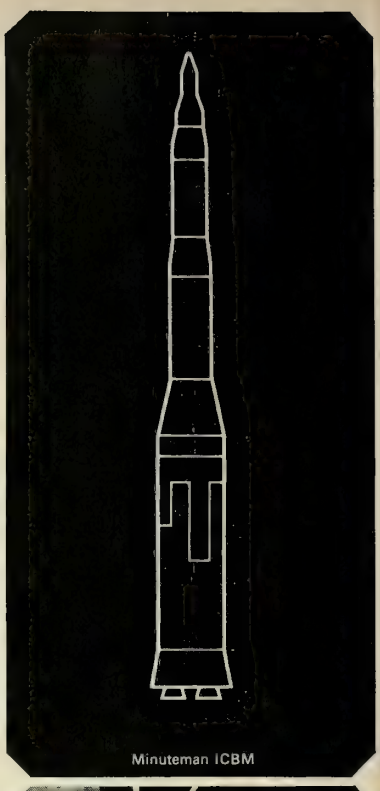


Saturn V Launch Vehicle

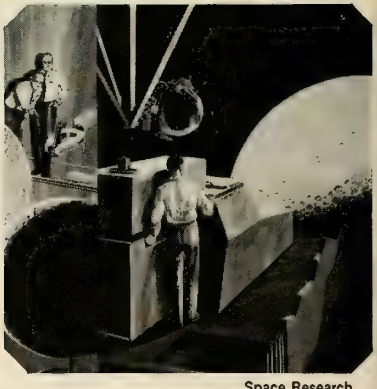


Lunar Orbiter



Minuteman ICBM

Space-Age Boeing Openings



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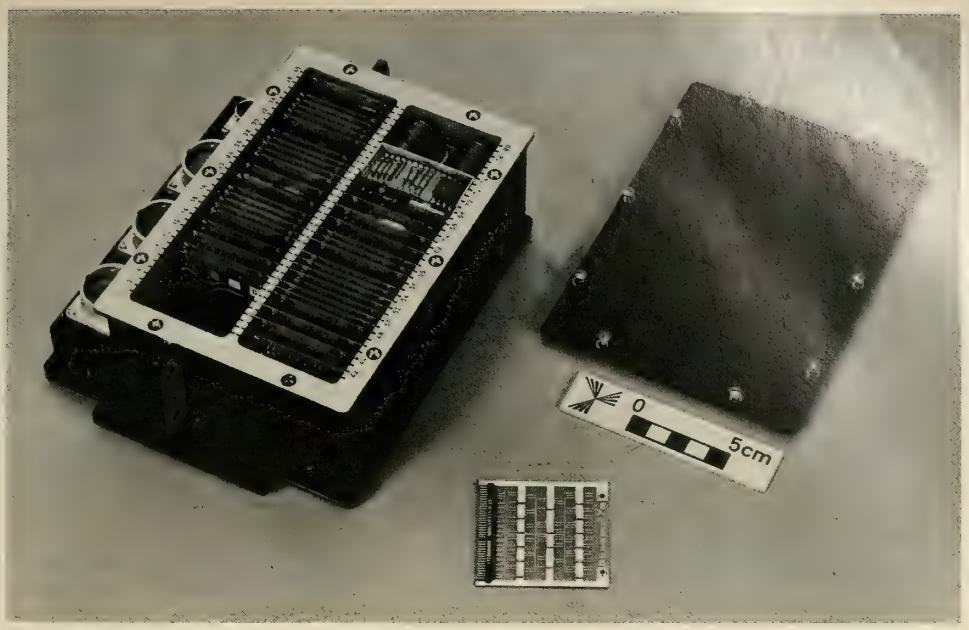

ON-BOARD PCM telemetry package, developed by Standard Elektrik Lorenz AG, will be first such unit to fly aboard German spacecraft. Unit, using integrated circuits, weighs about 3½ lbs. and will provide 18 channels.

German space project. The one-stage booster will be provided by ERNO.

While Dornier has been the major contractor involved in 621 since the program's inception, the government more recently has supported work on alternate concepts at Boelkow. The current Boelkow approach is reportedly based on a fixed-wing type of recovery system using small spoilers on the control surfaces. The system also is said to use radio command and is believed to be approaching the drop-test stage.

Government funding of the 621 project from the outset has been conservative. About $1.5-1.7 million has been spent thus far, and Dornier estimates that the cost to completion will total $4-4.5 million.

● **Specs**—The operational version of the Dornier 621 system will be 17 ft. long, including the 1-ft.-dia. boost stage, which remains attached throughout the flight. The engine will develop about 2½ tons thrust, will burn for about 11-12 secs., achieving a maximum acceleration of 15-20 g's, and will coast ballistically to a peak altitude of 48 mi. The vehicle internal frame will be steel with a glass-filament-wound outer structure and probably a titanium heat shield surrounding the nose cone. The four fins will be of aluminum honeycomb construction, though plastic type fins will be used in the test series.

The vehicle will weigh 400 lbs. fully fueled and will have a re-entry weight of about 152 lbs.

The rocket's paraglider will be automatically deployed via a pressure sensor at 48 mi. Peak velocity expected during the return flight phase is Mach 2.5; however, Dornier engineers expect no difficulty with glider deployment at high speed due to the low air densities. Prior to final flight tests, the system will also be put through a series of ground launchings using a standard solid-propellant booster which will provide flight experience to 18-mi. altitudes and into the Mach 1.3-1.5 region.

At paraglider deployment, the vehicle's four fins will also move to predetermined positions. Actual stabilization of the vehicle through interaction of the atmosphere and control surfaces is expected to begin at about 24 mi., and will continue through the 12-mi. level, under which radio command guidance will begin.

● **Tracking**—The Telefunken ground system will include three separate tracking receivers and a transmitter which will operate on three different modulation frequencies. The vehicle will retransmit the tracking signals. The triangulation receiver arrangement will allow both coarse and fine position measurements, according to Dornier, with the time phase also used for height finding.

Flight path, both predicted and actual, will be displayed at the control station, and a control stick will be used to initiate commands to the vehicle which will move the fins away from initial positions as required. From the 12-mi. altitude, the vehicle will be brought first into a 7.2-mi.-high, 3-mi.-wide corridor from which it is hoped that it will descend in a circular pattern to a landing.

The vehicle is designed to descend at about 20-25 fps, with maintenance of an angle of attack of between 20-25 degs, and a 3-5 deg angle with respect to the horizon.

The landing velocity expected is about 48 mph, according to Dornier, with a peak impact acceleration between 5-8 g's; however, this latter figure would depend significantly upon the type of terrain. Total flight time is estimated at 25 minutes.

The rocket's elevators will be able to move through ±14 degs from their initial position in response to ground commands, and the rudders will have about ±2-3 degs of freedom.

The paraglider is a plastic-coated fabric in a semi-conical shape, 7.5 ft. long and swept back 140 degs from the airframe. The total wing surface area is 100 sq. ft.

Still undecided is whether or not to actually land the vehicle by use of conventional parachute deployed once the craft has been brought to under a 660-ft. altitude. Dornier says a parachute is likely to be installed in any case for safety reasons.

Dornier engineers say the company is also supporting internal studies aimed at possible adaptation of the 621 system as an unpowered upper stage aboard other sounding rockets, such as the British *Skylark* or the French *Centaure*, to provide increased recoverable payload capabilities. Its use in this role, however, requires solution of potential instabilities caused by the extra length of the complete 621 system when used only as a nose cone. ■

AIR FORCE

$27,200,000—**Radio Corp. of America,** Camden, N.J., for work on ballistic missile early-warning system.

$10,000,000—**North American Aviation, Inc.,** Anaheim, Calif., initial segment of a $103 million contract for design and development work on the *Minuteman* missile.

$10,000,000—**Pan American Airways,** New York City, initial segment of a $124-million contract for operation and maintenance services at the Eastern Test Range, Patrick AFB, Fla.

$5,500,000—**Lockheed Aircraft Corp.,** Redlands, Calif., to design and develop a 156-in. solid rocket motor.

$3,728,410—**The Boeing Co.,** Seattle, for engineering work on the *Minuteman* missile program.

$3,557,721—**Astrodata Corp.,** Anaheim, Calif., for advanced range-testing at White Sands Missile Range.

$3,126,145—**The Bendix Corp.,** Detroit, for continued operation and maintenance of communications systems at Western Test Range.

$3,006,414—**General Tire & Rubber Co.,** Aerojet-General Corp., Akron, Ohio, to produce advanced storable liquid-propellant rocket engines.

$2,765,200—**Western Electric Co.,** Burlington, N.C., for production of *Titan III* guidance equipment.

$2,001,135—**North American Aviation, Inc.,** Anaheim, Calif., for engineering work on *Minuteman* missiles.

$1,217,515—**Laboratory For Electronics,** Danvers, Mass., to make radar test sets.

$1,000,000—**Philco Corp.,** Palo Alto, Calif., increment on a $3-million contract for work on an unspecified satellite program.

$400,000—**Informatics Inc.,** Sherman Oaks, Calif., to evolve a system for on-line computer use.

ARMY

$8,135,430—**General Electric Co.,** Syracuse, N.Y., for mobile acquisition radar.

$3,557,721—**Astrodata Inc.,** Anaheim, Calif., for total range requirements for advance range testing, reporting and control at White Sands Missile Range.

$3,500,000—**Universal Match Corp.,** Unidynamics Div., St. Louis, for production of *Pershing* missile erector-launchers.

$2,996,760—**Dynalectron Corp.,** Washington, D.C., increment to a $15.7-million contract for data collection equipment to be installed mostly at White Sands Missile Range.

$2,928,066—**Western Electric Co.,** New York City, to modify target track radar in Kwajalein Island.

$2,383,272—**J. R. Francis, General Contractor, Inc.,** El Paso, Tex., for range instrumentation facilities at White Sands Missile Range.

$2,013,000—**Martin Co.,** Orlando, Fla., for additional *Pershing* missile ground support equipment.

$1,594,081—**General Dynamics Corp.,** Pomona, Calif., for engineering on *Redeye* missiles.

$1,364,000—**Western Electric Co.,** New York City, for support of missile test firing program at White Sands Missile Range.

$1,322,209—**Hughes Aircraft Co.,** Fullerton, Calif., to make spare parts for The Mark IB satellite communications terminal.

$1,066,563—**Westinghouse Electric Corp.,** Pittsburgh, to install radar equipment at White Sands Missile Range.

$1,045,518—**Electronics Specialty Co.,** Los Angeles, to make telemetry systems.

$1,000,000—**Honeywell Inc.,** St. Petersburg, Fla., for a classified electronics program.

$550,669—**General Electric Co.,** Missile and Space Div., Philadelphia, for 8-month ARPA-sponsored research for optical system studies for terminal defense.

$142,283—**Ryan Aeronautical Co.,** San Diego, Calif., two contracts for hybrid propulsion research.

$76,599—**Sperry Rand Corp.,** Salt Lake City, Utah, for *Sergeant* missile system.

$30,503—**Northrop Corp.,** Newbury Park, Calif., for research on nuclear effects on instrumentation.

NAVY

$65,507,469—**Radio Corp. of America,** Camden, N.J., to make tropospheric scatter-communications systems.

$30,609,986—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for engineering work on the *Polaris* missile system.

$10,600,000—**Thiokol Chemical Corp.,** Reaction Motors Div., Denville, N.J., to continue production of packaged liquid rocket engines for *Bullpup* missiles (Navy and Air Force).

$9,222,152—**Raytheon Co.,** Waltham, Mass., for continued production of airborne control systems of the *Sparrow III* air-to-air missile.

$3,352,735—**Hughes Aircraft Co.,** Fullerton, Calif., to make shipboard satellite-communications sets.

$3,288,300—**Westinghouse Electric Corp.,** Pittsburgh, to design and manufacture reactor plant components for nuclear-powered vessels.

$2,893,396—**Farmers Tool & Supply Co.,** Denver, to make components for 2.75-in. rockets.

$2,373,556—**American Telephone and Telegraph Corp.,** Western Electric Co., Burlington, N.C., to produce shipboard weapon-control equipment for *Tartar* missiles.

$2,184,183—**Norris Thermador Corp.,** Los Angeles, for motor tubes for 2.75-in. rocket.

$1,923,840—**Atlantic Research Corp.,** Gainsville, Va., to manufacture rocket motors for *Terrier* missiles.

$1,426,794—**Dynatronics, Inc.,** Orlando, Fla. to make automatic tracking antennas.

$1,100,000—**Astrodata Corp.,** Anaheim, Calif., to make telemetry systems.

$922,000—**American Electronic Laboratories, Inc.,** Colmar, Pa., for AN/USM-117 transistorized oscilloscopes.

$200,000—**National Engineering Science Co.,** Pasadena, Calif., for studies of characteristics of novel configuration re-entry bodies.

NASA

$957,600—**American Machine & Foundry,** Advanced Products Group, York, Pa., for *Apollo* docking test device.

$300,000—**Avco Corp.,** Wilmington, Mass., for a feasibility study of an experiment for determining the properties of the Mars atmosphere.

$168,354—**The Boeing Co.,** Huntsville, Ala., for research on passive instrumentation and stimuli generation for *Saturn V* equipment checkout.

$150,000—**Melpar, Inc.,** Falls Church, Va., for development program to provide flight food for *Apollo* and LEM space vehicles.

$110,924—**Hughes Aircraft Co.,** Research and Development Div., Culver City, Calif., for space environment fabrication and repair techniques.

$78,095—**IIT Research Institute,** Chicago, for study of noise generation and turbulent fluxes on *Saturn IB* and *V* exhausts.

$70,000—**General Dynamics Corp.,** Convair Div., San Diego, for study of life support system for space missions exceeding one year in duration.

$70,000—**Lockheed Aircraft Corp.,** Missiles and Space Co., Palo Alto, Calif., for study of life support system for space missions exceeding one year in duration.

$62,460—**Electro-Optical Systems, Inc.,** Pasadena, Calif., for design of a solar reflecting beacon.

$62,268—**Consolidated Controls Corp.,** Bethel, Conn., for design, fabrication and delivery of a hot gas flow system.

$59,000—**General Electric Co.,** Missile & Space Div., Philadelphia, for evaluation of contact conductance at critical joints in the *Apollo* spacecraft.

$58,858—**Standard Pressed Steel Co.,** Jenkintown, Pa., for investigation of advanced high-strength alloys used in weight reduction of the *Saturn V* thrust structure.

$54,288—**Bryson Construction Co.,** Decatur, Ala., for construction of optical test system.

$44,843—**Northrop Corp.,** Northrop Space Laboratories, Hawthorne, Calif., for *Apollo* heat shield degradation study.

INDUSTRY

$7,000,000—**Douglas Aircraft Co.,** Los Angeles, from **North American Aviation, Inc.,** El Segundo, Calif., to produce a propellant-utilization system for the S-II stage of the *Saturn* lunar launch vehicle.

$600,000—**Beckman Instruments, Inc.,** Richmond, Calif., from **Douglas Aircraft Co.,** Missile and Space Systems Div., Los Angeles, for a hybrid analog-digital computer to be used in development of the *Saturn* rocket.

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Journal	137	155	−11.6
Air Force	198	263	−24.7
	1148	1089	+ 5.4%

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MISSILES AND ROCKETS*	**454**	**439**	**+ 3.4%**
Aviation Week & Space Technology	1257	1275	− 1.4
Space Aeronautics	383	523	−26.8
	2094	2237	− 6.4%

AVIATION PUBLICATIONS

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AMERICAN AVIATION*	**264**	**222**	**+18.9%**
Flying	286	242	+18.2
B/CA	280	241	+16.2
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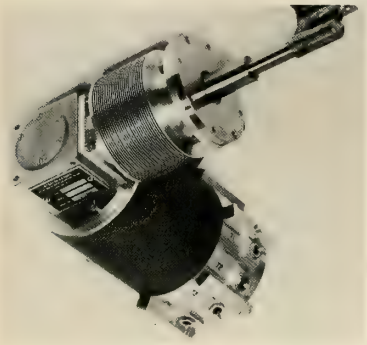

A miniaturized cryogenic refrigerator designed for cooling infrared devices, parametric amplifiers and lasers is being marketed by Cryogenerators, a division of North American Phillips Co., Inc.

The Model 42115 CRYOGEM® can also be used for cryopumping, hydrogen and neon liquefaction and recondensation of cryogenic fluids, developers point out. The unit weighs 30 lbs. and measures 7 x 11 x 13.75 in., including motor. Net effective refrigeration is 1 watt at 25°K or 3 watts at 30°K. Cycle is 1,000 hours MTBF. Motor is 3-phase, 208v, 60 cps; power input is less than 500 watts.

The working fluid is standard grade A helium at a pressure of 125 psig. The unit is cooled by use of fins, but liquid cooling is available.

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Voltage Calibrator

The Model 278A voltage calibrator for use with both airborne and ground voltage-controlled oscillators is being marketed by Electro-Mechanical Research, Inc.

The unit is available in three models. The 278A-01 provides a single 5-v output range switchable to 5 deviation positions for one of three offset conditions: -5 to 1, -2.5 to 2.5 and 0 to 5v. The 278A-02 offers two output voltages simultaneously in two separate offset ranges: -5 to 0 and 0 to 5v. The 278A-03 provides three simultaneous outputs, one in each of the three offset ranges.

All outputs are within ±0.1% of initial values over temperature ranges from 10° to 50°C. Output noise is less than 1 millivolt RMS; output current can be up to 50 ma on each output.

Circle No. 152 on Subscriber Service Card

Ferroresonant Power Supply

A series of ferroresonant power supplies covering 9 voltage and current ranges is being marketed by Trygon Electronics, Inc.

The units are available in two configurations and provide ranges from 6v, 25 amps, to 300v, 0.5 amps. The FTR series is packaged in a standard quarter rack configuration; the FT series is a module version for systems with minimum space available. Both series feature ±1% line regulation, series or parallel operation, 1% stability and operation up to 55°C.

Circle No. 153 on Subscriber Service Card

Slip-Ring Assembly

A subminiature slip-ring assembly, designed to operate for 100 million revolutions at 1,800 rpm without servicing, has been developed by Electro-Tec Corp.

The 22-circuit assembly features slip-ring surfaces of electrodeposited "fine" silver and silver graphite brushes mounted on dual cantilever beryllium copper springs. Individual brush blocks have screw-on type terminals.

Units can withstand shocks of 15 g's vibration from 10 to 55 cps and operate over a temperature range of 0 to 55°C. The device measures 3.65 in. long and 1.75 OD and weighs 9 oz. It is rated at 5 amps, 115v, with variation in contact resistance (noise) of 20 milliohms peak.

Circle No. 154 on Subscriber Service Card

Receiver Protection Unit

An HF receiver pre-selection and protection unit that attenuates interfering signals 100 db or more has been introduced by RACAL Communications, Inc.

The Type MA-197 covers frequencies from 2 to 24 mc. Inserted between antenna and receiver input, it provides pre-selection to reduce adjacent channel interference and intermodulation products. For an unwanted signal 5% off tune, an attenuation greater than 95 db is achieved. The device can withstand up to 40 v.

It consists of three selective, double-tuned circuits with air space coils and

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condensors coupled by cascade amplifier stages. Frequency is covered in four bands: 2-4, 4-8, 8-16 and 16-24. Overall gain is 6 db minimum.

Circle No. 155 on Subscriber Service Card

Porcelain Capacitors

Vitramon, Inc., has developed a line of high-current porcelain capacitors, designed specifically for maximum RF current operation.

The "VY" series units offer a dissipation factor of 0.001 maximum at 25° C and 0.003 maximum at 125°C. Current operation up to 22 amps RF with uniform heat dissipation throughout a temperature range of —55° to 125°C is possible. Capacitance values range from 10 to 2,000 pf; voltage ratings are to 2,000v ac RMS and 500v dc. Tepperature coeffiicient is 105 ppm/°C ±25ppm/°C.

The units are available in six case sizes. Insulation resistance exceeds 100,000 megohms.

Circle No. 156 on Subscriber Service Card

Image Pickup Tube

A 3-in. image dissector pickup camera tube with a resolution of 3,000 television lines per inch is available from Westinghouse Electric Corp.'s Electronic Tube Div.

The Model WL-23111 is especially suited for microfilm readout, television

film scanning and high-speed flying-spot scanning, developers say. Ruggedness and lifetime are increased by the elimination of a target or hot cathode to deteriorate. A zoom effect can be attained electronically by magnification through scan reduction. Resolution is the same as that for the original area. No change in light level is necessary during the underscan operation.

In operation, an electronic picture corresponding to the optical image focused on the faceplate is emitted from the photocathode. The electronic picture is scanned across an aperture and, at any instant in time, only the electrons passing through the aperture enter the electron multiplier. Quantity varies with the light intensity on the image portion being scanned. Further amplification is accomplished by a secondary emission in the 12-stage multiplier section.

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names in the news

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Roy J. Benecchi: Named vice president and general manager of Aeronca Manufacturing Corp., Middletown Div. He was formerly president of Clavier Corp.

Walter O. Stanton: Elected to the board of directors of Servo Corp. of America. He is president of Pickering and Co., Inc.

Dr. Victor A. Babits: Appointed vice president of research for Marshall Laboratories, a subsidiary of Marshall Industries.

Shannon C. Powers: Named vice president of Cook Electric Co., and general manager of its Tech-Center Div.

Ellsworth Smith and **Henry Piper:** Elected vice presidents of The Brush Beryllium Co. Smith was a founder of Penn Precision Products and PennCast, both of which were merged with Brush in 1958. Piper formerly was with Olin Mathieson Chemical Corp.

G. A. Spiro: Elected vice president of operations for the Permacel Div. of Johnson & Johnson.

William H. Heflin: Elected president and general manager of Beckman & Whitley, Inc., a wholly owned subsidiary of Technical Operations Inc.

Dr. Harold Chen: Named chief research scientist by U.S. Polymeric, Inc. He will be responsible for direction of research in the company's development of high-temperature structural and ablative composite materials.

Emory C. Bennett: Re-elected vice president of the American Society for Quality Control. He is chief of quality control engineering at the Norair Div. of Northrop Corp.

David H. Robinson: Appointed to the newly created post of general manager of Lundy Electronics & Systems, Inc.'s recently acquired subsidiary, McMillan Corp. He was formerly with Radio Corp. of America.

George E. Manis: Promoted to chairman of the board of Model Engineering & Manufacturing Corp. Also involved in the general realignment were **Marvin B. Ruffin,** elected president and chief executive officer; **Joseph H. Lesh,** secretary; and **Theodore B. Price,** who joined the company July 1 as treasurer.

Benjamin F. Moore: Appointed program manager for Westinghouse Electric Corp.'s manned submersible program.

Michael J. Samek: Appointed director of the International Div. of Auerbach Corp.

John W. Lazur: Elected president of the Boston chapter of Armed Forces Communications and Electronics Association. He is Raytheon Co.'s Space and Information Systems Div. marketing manager.

James J. Sullivan: Named a vice president and assistant treasurer of Silicon Transistor Corp. He was formerly staff assistant to the president.

R. Murph Jones: Appointed to the newly created position of director of nuclear products with Monsanto Research Corp.

A. Henry Casey: Promoted to the position of assistant to the executive vice president of Lear Siegler, Inc.

Raymond L. Bisplinghoff: Named 1965 von Karman Lecturer by American Institute of Aeronautics and Astronautics. He will deliver the lecture at AIAA's Second Annual Meeting, July 26-29. He is an associate administrator of NASA. **Werner R. Kirchner,** who led the rocket design team for the *Polaris,* will receive the James H. Wyld Propulsion Award at the June 16 AIAA Propulsion Joint Specialist Conference. He is vice president and manager of solid rocket operations at Aerojet-General Corp.

Roy E. Danielson: Died June 26, at Prince Georges General Hospital, Hyattsville, Md. He was a guided missile expert and chief engineer of the missile branch of the Special Projects Office of the U.S. Navy. At the time of his death he was involved with work on *Poseidon.* He was awarded the Navy Distinguished Civilian Service Award for his work on *Polaris,* and had been associated with the initial development of *Terrier, Talos* and *Tartar* missiles.

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The Impact of Educational Technology, sponsored by American Management Assn., The Americana Hotel, New York City, July 12-16.

Gordon Research Conferences (Chemistry and Metallurgy of Semiconductors), Andover, N.H., July 12-16.

Annual IEEE Conference on Nuclear and Space Radiation Effects, sponsored by the Institute of Electrical and Electronics Engineers, University of Michigan, Ann Arbor, July 12-16.

Advanced Science Seminar in Experimental Techniques in High-Speed Aerodynamics and Gas Dynamics, sponsored by the National Science Foundation, Ohio State University, Columbus, July 12-23.

Aerospace Vehicle Flight Control Conference, sponsored by the Society of Automotive Engineers and NASA, International Hotel, Los Angeles, July 13-15.

European Space Symposium, sponsored by Eurospace, in conjunction with the International Exhibition of Transport, Munich, July 19-22.

Second Annual Meeting and Technical Display of the American Institute of Aeronautics and Astronautics, Civic Center, San Francisco, July 26-29.

Aerospace Reliability and Maintainability Conference, sponsored by the American Society of Mechanical Engineers, American Institute of Aeronautics and Astronautics and the Society of Automotive Engineers, Statler Hilton Hotel, Los Angeles, July 28-30.

AUGUST

Eighth Annual Space Technology Institute, sponsored by Air Force Systems Command, NASA, and University of Connecticut, University of Connecticut, Storrs, Aug. 1-13.

Tenth Technical Symposium, sponsored by Society of Photo-optical Instrumentation Engineers and Air Force Systems Command, Jack Tar Hotel, San Francisco, Aug. 16-20.

1965 National Meeting of the American Astronautical Society, Sheraton Palace, August 18-20.

International Lunar Geological Field Conference, sponsored by University of Oregon and New York Academy of Sciences, Bend, Ore., Aug. 22-28.

Conference on the Exploration of Mars and Venus, sponsored by Virginia Polytechnic Institute, NASA, and Air Force Cambridge Research Laboratory, Blacksburg Va., Aug. 23-27.

1965 Western Electronic Show and Convention (WESCON), San Francisco, Aug., 24-27.

1965 International Antenna and Propagation Symposium, sponsored by Institute of Electrical and Electronics Engineers, Sheraton Park Hotel, Washington, D.C., Aug. 30-Sept. 1.

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A European Space Proposal

STEVENAGE, ENGLAND

VISIBLE SIGNS of European space progress can be found at the Hawker Siddeley Dynamics plant in this Hertfordshire industrial town.

Here, detailed design of the European Space Research Organization satellite known as *ESRO-II* is under way.

Here, too, engineering prototypes of the European Launcher Development Organization booster and its satellite are being integrated for the first time.

But despite these evidences of European space cooperation, the same divisive influences apparent at the Eurospace meeting in Philadelphia this April still are at work.

The basic problem remains the same. Some members of the European space community want to press ahead immediately with the *Aerospace Transporter*, seeing it as the only path for Europe to follow in order to become a true third power in space. Others regard it as far too ambitious a project, both technically and financially.

The first group believes that only a major manned project will attract the necessary public and political support. Their views were manifested at the recent Paris Air Show in the form of four models on display. These included the three-stage French Dassault design, calling for liquid hydrogen-fueled turbine-rocket engines for all three stages; the Junkers two-stage German piggyback approach; the British Bristol Siddeley craft to be launched by a solid rocket atop the fuselage; and a two-stage vehicle designed by France's Nord Aviation and Germany's Erno with the second stage carried as a belly pod.

Supporters of these proposals believe *Aerospace Transporter* can be undertaken on a step-by-step approach developing the necessary technology in the process. Cost of the project has been estimated at an average of $100 million a year over a 10-15 year period, a figure probably much too low.

Nevertheless, there is reason to believe Europe could support such a program financially, if so motivated. Present space spending is about $140 million annually, only 0.03% of Europe's collective Gross National Product, which totals three-fourths that of the U.S., now spending 1% of its GNP on space. There is, therefore, considerable room for an increase in European space spending, both nationally and internationally, if the various governments can be convinced it is worthwhile.

There is, in fact, a third approach possible to a major European space program. It has been skirted from several angles but has yet to crystalize. Geoffrey Pardoe, chief project engineer of the Space Projects Div. at Hawker Siddeley, touches upon it when he foresees international cooperation in space between the U.S. and USSR once the race for a lunar landing is over. He believes that the sheer expense of further space exploration will force this international cooperation once the competitive aspect has dissipated; he feels that approaching projects are too large for even the two leading nations to finance alone.

"Since such work will involve creating staging bases on the Moon and in orbit around the Earth," says Mr. Pardoe, "perhaps Europe might accept some responsibility in providing certain specialized logistic support for these internationally manned bases using rockets and spacecraft developed out of the present national and international programs."

A similar approach was foreseen in the discussions on a *Lunar International Laboratory (LIL)* at the International Astronautical Federation meeting two years ago. This is again on the IAF agenda at Athens this fall.

Yet, granting the capacity of Europe to finance a major manned space program, there is a direct route to original, practical and immediate European participation in space which has not yet been considered. That is for Eurospace to propose through ELDO or ESRO to the UN Committee on Peaceful Uses of Outer Space that development of the manned lunar base be undertaken as the European contribution to an international lunar exploration program. The U.S. and the Soviet Union would contribute to this by supplying the boosters, spacecraft and launches in logistic support of what could begin as a one or two-year project. Each nation, if it felt compelled to do so, still could establish its own lunar base.

THERE ARE MANY appealing aspects to such a proposal. It would make Europe a major partner in space, contributing a financial share which would be welcome to both the U.S. and Soviet taxpayers. Europe could begin work immediately on a manned space project, one not only with popular appeal and within its scientific and technical scope but which has not yet gone beyond the study stage in the U.S. or, apparently, in the Soviet Union. The project also has the advantage of overcoming the *bête noire* of other international proposals in that it would require no physical meshing of the space programs of the U.S. or USSR, which could alternate in providing cargo and passenger launches from their own bases.

The UN Outer Space Committee already is setting precedent as the body for such a proposal by its sponsorship of internationalization of such national ranges as India's Thumba and possibly Argentina's Chamical. Chances of U.S. acceptance of such a proposal would be excellent. In the face of U.S. agreement, it would be difficult for Russia to turn it down. Nor would there be any compelling reason to do so.

The first step required is a European proposal in the UN for a feasibility study of such a manned lunar base project. A detailed program then could be presented for acceptance. At that point—not in 10 or 15 years—Europe would have on its hands a major and exciting manned space program.

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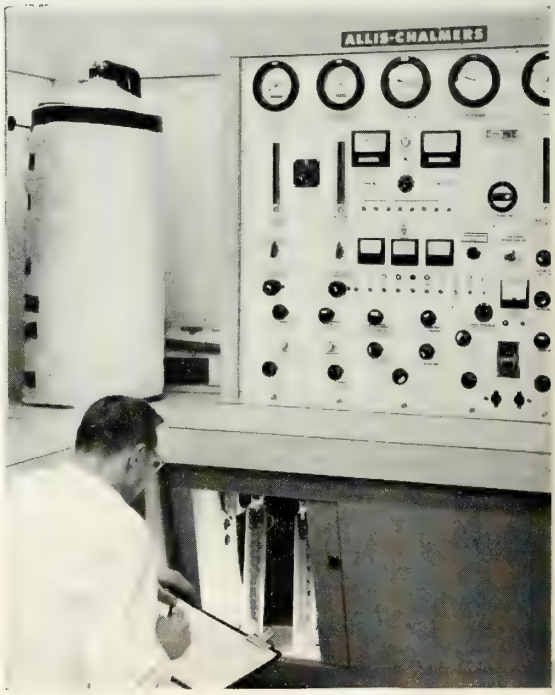
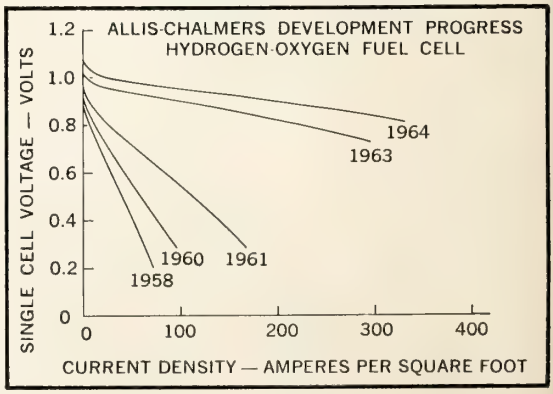


A-C research scientist logs the production of drinking water during 1,400-hour testing of the 28-volt fuel-cell system.

Chart shows Allis-Chalmers fuel-cell technology has improved by an order of magnitude since 1958.



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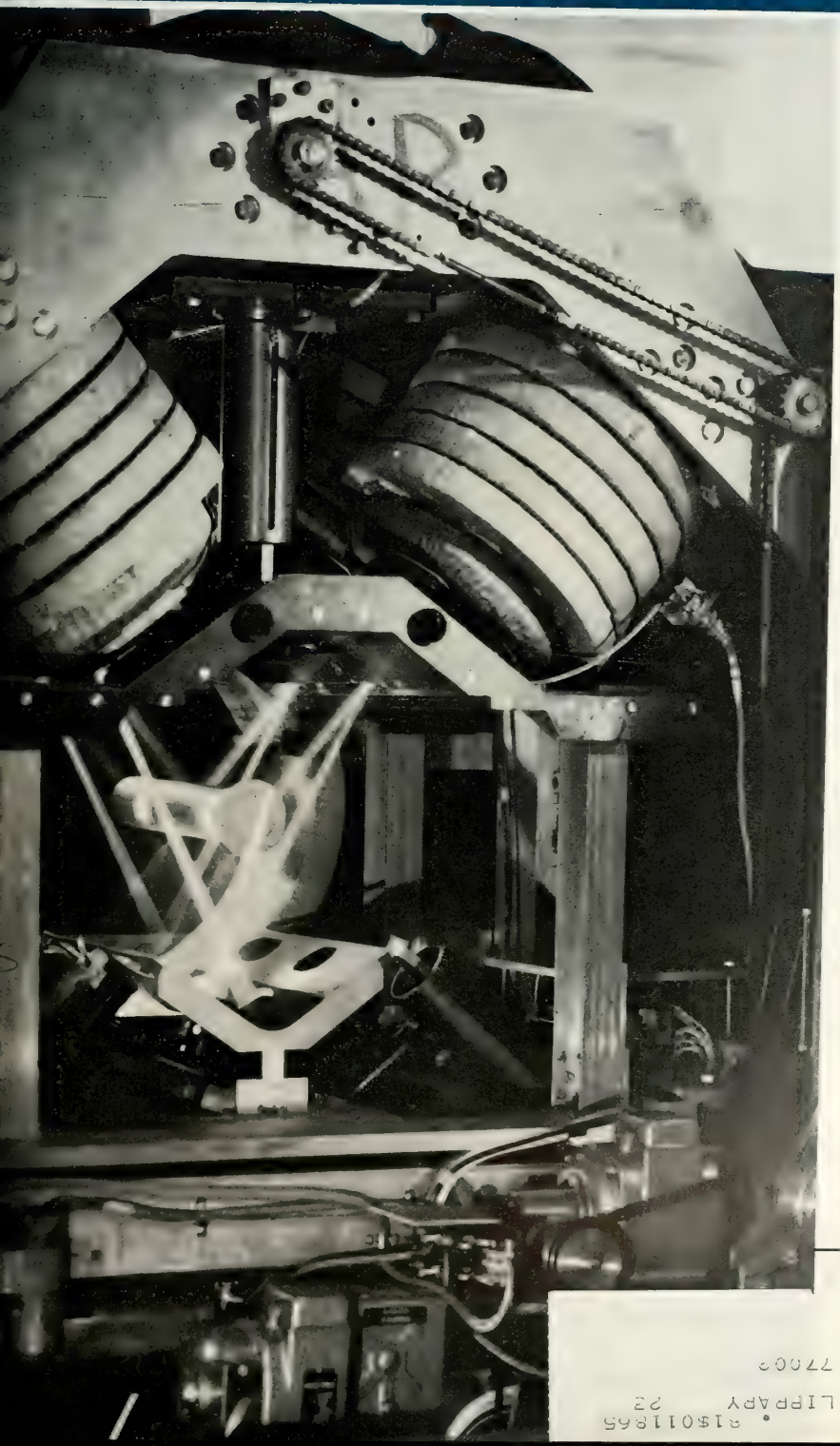

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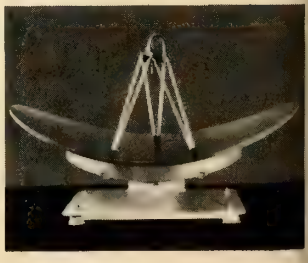

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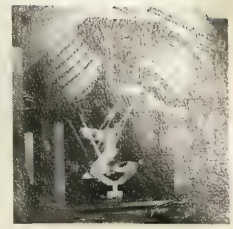
THE COVER



French Mach-7 wind tunnel employs electromagnets to suspend test model. Current in magnetic coils is monitored by photo cells that receive a beam of light, the cross-section of which is altered by movement of model. Office National d'Études et de Recherches Aérospatiales supports program.

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letters

Mariner Photos

To the Editor:

We protest the decision taken by NASA and Jet Propulsion Laboratory to withhold the high-quality photographs taken by *Mariner IV*. Since these organizations are tax-supported, it behooves them to release their findings as quickly as possible. We feel that is altogether improper for Government agencies to withhold information from the public in situations such as these, where public interest is keen and national security is not compromised.

Further, the concept of "a proprietary right to scientific information" is alien to the scientific community. Is it possible that the photographs are being withheld until a select group have published their analyses in technical journals?

We hope that NASA will not continue this policy of withholding scientific information unrelated to our national defense, especially in view of the *Ranger* coverage.

T. F. Hughes
R. R. Rice
St. Louis, Mo.

Patent Policy

To the Editor:

At this time, when we are in a vital contest for world technological supremacy that will determine the future of our country, Sen. Russell B. Long (D-La.) has offered an amendment (S-1899) relating to our Federal patent policy that is logical and practical for the following reasons:

(1) If Equality is really and truly the foundation of American Democracy, then American companies should waive patent rights to inventions made at Government expense just as the said companies compel their employees to waive patent rights to inventions made by them during their employment.

(2) The recurrent theme that American companies would have to give up previously acquired knowledge is plain hogwash. Companies which do not apply for patents on inventions in their possession prior to their seeking Government contracts deliberately and intentionally retard the technological progress of the United States of America by violating Article I, Section 8 of the United States Constitution, which was specifically enacted to *promote the progress of science and the useful arts.*

(3) The assertion that Sen. Long's amendment discourages inventive effort is another example of the Big Lie. During the week of June 10, 1963, there was a conference on "Science Creativity" at New York University in an effort to find ways and means for increasing our technological creativity, which is at a low ebb for reasons indicated in the report to the Senate Subcommittee on Patents, Trademarks, and Copyrights, Study No. 30, 87th Congress, Second Session (1963). The reason, therefore, is that the original intuitive concepts of inventors constitute the foundation on which engineers and scientists then erect specific structures; and therefore captive inventors will continue to give less than their best efforts for as long as they are treated as serfs. As a lengendary Chinaman once said: "No tickee—no shirtee."

Harry Bricker Fuchs
Farmingdale, N.Y.

Missiles in Viet Nam

To the Editor:

Many of your readers must be as interested as I am in our experience with missiles so far in the Vietnamese involvement.

I am somewhat aware of the security considerations involved, but would like to see a roundup of the missile side of the story, even if only a collection and elaboration of the bits that have appeared in the daily press—concerning *Sidewinders* and *Bullpups,* mainly.

Thor Garsson
Milwaukee

Reprints of NASA Report

Reprints of the entire Special Report on NASA's new Electronics Research Center published in the May 31 issue of MISSILES AND ROCKETS *may be obtained from:*

Research Department

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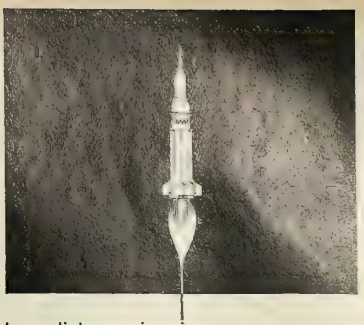

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Above positions require
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Primary experience should be in unsteady phenomena such as aerodynamic noise and vibration. Will direct prediction of complete aerodynamic environment of Saturn and advanced Saturn vehicles. Also direct the establishment of shock and vibration criteria corresponding to the predicted environment, including acoustics and buffeting. Minimum 5 years experience.

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will be conducted
during the AIAA Meeting
To arrange for an interview,
call Mr. S. J. Kochanek
at 771-1400 in San Francisco
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The Countdown

WASHINGTON

Air Force Optimistic over Brown Appointment

Appointment of Dr. Harold Brown, director of Defense Research and Engineering, as Secretary of the Air Force effective Sept. 30, hasn't cast the gloom over the service that might have been expected. AF officials known Brown as the man who de-emphasized and cut back the B-70 program, cancelled *Dyna-Soar,* and joined Secretary McNamara in not protesting much when Congress eliminated *MMRBM.* But many of them feel that they may benefit from added scientific and technical competence in the top administration post. They cite the case of Paul Nitze, widely regarded as a theorist with first allegiance to McNamara policy, who confounded the prophets by proving to be a highly effective advocate of new systems and budget support when he became Secretary of the Navy.

S-IC Saturn Firing Slips

First full-duration firing of the S-IC stage of the *Saturn V* booster has slipped two weeks—from mid-July to early August. It will be preceded by a 40-second firing of the five-F-1-engine combination in the last week of this month. If that is successful, the full 2½-minute firing will follow shortly thereafter. The tests have been delayed by late delivery of components for the flight pressurization system that is being installed.

Taylor in Line for Apollo Extension Post

William B. Taylor is expected to be named director of the *Apollo Extension Systems* Office when it is established in the near future in the Office of Manned Space Flight at NASA headquarters. He has been in charge of Special Studies in the Office of Advanced Manned Missions. The *AES* office probably will report to the Deputy Associate Administrator for Programs, Brig. Gen. David M. Jones.

Viet Nam Supplemental Whether or No?

Senate Defense Appropriations subcommittee has given notice that it may put extra funds in the FY 1966 defense appropriations bill to cover the Vietnamese escalation whether the Secretary of Defense asks for a supplemental or not. Irked by McNamara's failure to respond to an invitation to come to Congress with such a request, Sen. John Stennis (D-Miss.), acting chairman of the subcommittee, has asked that the Secretary come before the subcommittee as soon as he returns from Viet Nam.

Chances Drop for Cislunar Satellite

Prospects for a cislunar satellite program have dimmed. NASA Associate Administrator Dr. Robert C. Seamans was briefed on the matter by Dr. George Mueller, associate administrator for manned space flight, and Milton Ames, director of space vehicles in the Office of Advanced Research and Technology. Ames declared the satellite was not needed; Mueller favored it. No final decision has been made, but it appears Seamans favors the Ames position. Fate of Ames's counter-proposal—a meteoroid satellite in high-altitude Earth orbit—is not known.

Langley To Simulate SST Landings

Langley Research Center will begin in the near future simulated landings of the Supersonic Transport using a Boeing 707 jet. The four-month program will be conducted on runways of the old Chincoteague (Va.) Naval Air Station near Wallops Island. Landings will test both the variable-sweep and fixed triangular wing concepts of supersonic design.

All Alone with Our Feet and Pounds?

Congressional proponents of a study on whether the U.S. should convert to the metric system are arguing that this may become virtually the only nation using another system of weights and measures. Great Britain has officially declared that it will switch to the metric system; Canada has indicated it will study the possibility. Bills to fund such a study in the U.S. are pending in both House and Senate.

INDUSTRY

GD/Convair Ponders Solids Acquisition

General Dynamics/Convair is reported contemplating the acquisition of capability in solid rockets. The division has brought *Atlas* through a succession of successful growth versions, and achieved a formidable cryogenic reliability record. But it needs more production hardware prospects to keep its San Diego plants working at present levels. Division president J. R. Dempsey has been addressing his efforts to creating new business ever since the recombination of the Astronautics and Convair divisions.

Hamilton Standard To Make Welder for Space

Hamilton Standard Division of United Aircraft Corp. has been selected by NASA to design and build a hand-held electron beam welder that could be used to repair and assemble spacecraft in orbit. It will join metal by firing highly concentrated electrons at a speed of 50,000 miles per second. Project will take 15 months and be worth $146,988. Welder probably will be carried on Project *Apollo* flights.

Sylvania To Build Radar on Roi-Namur

DOD has awarded Sylvania Electronic Systems a $16,-252,374 contract for design, fabrication and installation of a new dual-frequency radar called ALTAIR (ARPA Long-range Tracking and Instrumentation Radar) on Roi-Namur Island of the Kwajalein Atoll. The ALTAIR will be operated in conjunction with the *Nike-X* project.

INTERNATIONAL

Italian Air Force Has Missile/Space Center

Weapons and Ammunition Division of the Italian Air Force has formed a Missiles and Space Research Center at a Roman airport. Its establishment marks the separation of Air Force missiles and space R&D from that of the Italian National Committee on Space Research, headed by prof. Luigi Broglio. The professor also directs the Space Center of the Italian Space Mission, located at the same airport, which was constructed with funds from NASA, the Italian Research Committee and the Italian Air Force.

SRAM Team Formed

The Martin Co. announced last week that it will form a team with IBM's Federal Systems Division and Litton Industries to compete for the Air Force *SRAM* (*Short Range Attack Missile*) program.

IBM will be responsible for design and construction of the missile guidance system and the required avionics, with Martin as prime. Litton's guidance and control systems division will be a subcontractor to IBM for missile and aircraft guidance platforms.

NASA Funds Survive Debate

An attempt on the Senate floor to cut the NASA FY 1966 appropriation by 5% created an intense debate last week, but resulted in no damage to the $5.19-billion fund approved by the Senate Appropriations Committee for NASA.

NASA's funds, along with other agencies in the Independent Offices Bill, were approved by the Senate and sent to conference with members of the House Appropriations Committee, who voted only $5.165 billion for NASA in their version of the bill.

The amendment to cut the bill—a reduction which would have amounted to $295.5 million—was offered by Sen. William Proxmire (D-Wis.), who was successful 2 years ago in pushing through a last-minute amendment that trimmed NASA by $90 million.

He argued this year that although popular climate is not conducive to a cut—with the *Gemini* flight, the *Mariner* excitement and anticipation of future space events—he felt that the program is one which "there has been a great deal of waste." He said that the space program has been generously funded for many years, and is one that "can stand some reduction."

Proxmire's move was defeated 61-16.

Nine Bid on Moon Package

Nine firms have submitted bids on the integration of the lunar surface experiments package (LSEP), which would be left on the Moon after the first U.S. lunar landing flights.

The Manned Spacecraft Center announced that bids have been received from Avco Corp., Northrop, Westinghouse Electric, General Electric, Space General, Bendix, Hughes, TRW Systems Group and Philco.

MSC said three firms would be selected for parallel Phase I efforts which will last six months. One will be selected late this year or early next year for hardware development.

Phase I will determine how best to integrate as many as nine scientific experiments into a box 1 x 2 x 15 ft. Included in the package will be the electronics to maintain the experiment in operation for up to 1 year after the first lunar landing mission. The LSEP, structurally a part of the Lunar Excursion Module (LEM), will be stowed in the descent stage of the LEM. It is one of two such packages reserved for scientific experiments. *Apollo* astronauts will remove the box and set it up for operation on the lunar surface prior to their departure.

Apollo Weight May Be Cut

A one-ton weight reduction on the *Apollo* spacecraft may be possible as a result of *Pegasus* meteoroid measurements.

According to John H. Disher, *Apollo* program test director in the Office of Manned Space Flight, data from *Pegasus I* and *II* have indicated that meteoroid flux in space is less that previously expected. Thus, NASA will be able to reduce the dry weight of the stainless foil outer curtain over the fuel tanks and other vulnerable areas by 100 lbs. This, plus the various resulting structural and fuel savings, adds up to a total weight reduction of one ton.

NASA officials reported that during the May 25-July 3 period, *Pegasus II* radioed back 73 verified meteoroid penetrations.

DOD Savings Pegged at $4.6 B

In briefing Washington newsmen last week on the progress of his Defense Department cost-saving program, Secretary McNamara said that $4.6 billion was saved during FY 1965—$2.1 billion more than DOD's established goal. The success of the program has resulted in establishment of a new long-range goal of $6.1 billion per year by FY 1969 and each year thereafter.

Asked whether his announced savings would result in a reduction in the next military budget (now in the process of initial preparation for FY 1967) McNamara replied, "everything else being equal, we can look for a reduced budget. But I don't know if everything else will be equal."

Shots of the Week

Air Force crews flying F-4C Phantoms using *Sidewinder* air-to-air missiles shot down two MIG-17 fighters 75 mi. northwest of Hanoi July 10. One of the Russian-made jets disintegrated when hit, and the other was seen smoking and in a steep dive.

- The French on July 5 successfully fired the two-stage *Saphir* rocket. The accomplishment indicates that the *Diamant* launcher, of which *Saphir* constitutes the first two stages, will be able to orbit the first French satellite, *A1*, before the end of the year.

Comsat Issues Station RFP's

Communications Satellite Corp. has requested proposals from 37 firms for architectural and engineering services for construction of ground stations at Oahu, Hawaii, and Brewster Flat, Wash.

Firms may submit designs for one or both stations. Deadline is July 27, and a contract for the architectural services is expected in a few weeks. Construction is scheduled to begin in September or October with completion planned by September, 1966.

The stations will require several buildings, including a control building, a visitors' center, water and sewerage facilities, roads and power lines.

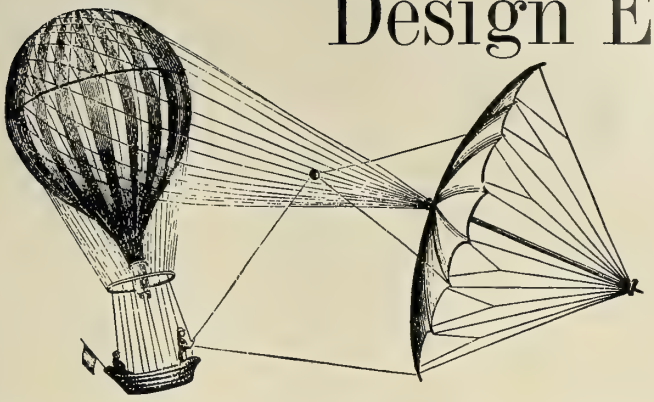
Comsat is also negotiating with American Telephone & Telegraph Co. for purchase of the ground station at Andover, Me.

Mariner Data Shared

New Englanders were geared up to receive a rare mixture of communications transmission techniques last week in conjunction with the *Mariner* Mars fly-by.

Data from *Mariner* were received at the Goldstone Deep Space Instrumentation Facility, relayed to the Jet Propulsion Laboratories' Pasadena Control Central and then sent directly to the Museum of Science in Springfield, Mass. There it was relayed directly on a laser beam over a 10-mi. path to TV Station WLP and then retransmitted automatically

Design Engineers!



Drifting behind the State-Of-The-Art?

Career opportunities at Hamilton Standard involve the caliber of advanced assignments that keep a man's career moving constantly forward, and provide stimulus and challenge for the individual. This rapidly expanding company (ground is being broken for 165,000 square foot addition) is busy with a wide range of important undertakings . . . space life support systems, engine controls, many other aerospace and commercial systems and components, aircraft and missile propulsion systems, ground support equipment and electron beam machines. This diversification creates stability and enhances growth opportunity. Our Connecticut countryside with its wealth of recreational facilities is considered one of America's most desirable living areas.

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VALVE DESIGNER. Assignments will be in field of pneumatic valve design. Inventiveness, knowledge of manufacturing methods and of materials, and analytic ability in mechanics, stress analysis, and fluid mechanics required. Previous experience should be in above field, preferably aerospace.

HEAT EXCHANGER DESIGNER. Knowledge of sheet metal fabrication methods, properties of materials, and analytic ability in mechanics and stress analysis of sheet metal structures required. Previous experience should be in aerospace metal structures or heat exchangers.

AIR INLET AND SPECIAL CONTROLS DESIGNER, ME or AE. Assignments in field of hydraulic and air inlet control systems design. Inventiveness, knowledge of manufacturing methods and materials and analytic ability in hydraulics, mechanics, stress analysis and servomechanisms required. Experience should be in above or related field—hydraulic controls, fuel controls or flight controls.

DESIGNER, ENGINE CONTROLS, ME or AE, BS desirable. Assignments in field of mechanical and hydraulic control system design. Analytic ability should encompass stress analysis, mechanics, hydraulics, and preferably servomechanism theory as well as fundamental thermodynamics. Previous experience should be areas of product design on control systems, instrumentation or computing mechanisms. Applicant must be capable of considerable growth capacity.

ADVANCED SPACECRAFT COMPONENTS AND SYSTEMS DESIGN involving atmosphere revitalization, fluid and heat transport, water management and reclamation of oxygen and water from waste products. Sound working knowledge of thermodynamics, fluid mechanics and mechanics is required. Duties will include trade-off studies for life support systems, creation of optimum schematics, and systems and component design.

ELECTRONICS DESIGN ENGINEER with experience in discreet type or digital controls design. Oriented in both analytical and hardware phases of design activity involved in closed loop digital control systems. Product applications involve jet fuel controls, synchrophasers, cabin pressure controls and similar aircraft and aerospace closed loop systems. Requires BSEE; MSEE preferred.

DESIGNER, TECHNICAL STANDARDS, to establish design procedures for product design/development regarding use of standard parts and component hardware; review design layouts, conduct technical audit of engineering contracts, establish special test programs and analyze data to evaluate performance of parts. Should be familiar with AN, MS and NAS standard parts and be able to conduct various related analytical design studies.

STRUCTURES DESIGNER to develop new concepts and design structures to support space life environmental systems for space vehicles. Will be required to plan and direct work of small design group. Requires experience in air frame design, including stress, shear panel and mono-coque construction and knowledge of plate and shell theory, and sheet metal, welding and rivet design.

TO ARRANGE AN INTERVIEW, please forward your resume, including present salary, to Mr. C. M. Ripley, Personnel Department, Hamilton Standard, Windsor Locks, Connecticut. We are an equal opportunity employer.

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Aerospace Components Division
Valley Forge, Pa. 19481

over the facility's 50,000-watt transmitter throughout New England.

Since November of last year, the Museum of Science—a non-profit foundation, sponsored by the city of Springfield and dedicated to the dissemination of scientific and technical progress information to the public—had been preparing for a series of programs associated with the *Mariner* Mars mission. Armed with a rather potent force of space and scientific experts, displays, interviewers and the only non-NASA two-way telephone link with JPL-Pasadena, the Museum was prepared to present nightly programs describing the event and its technological meaning.

To add a little more "gee whiz" to the event and also provide a practical demonstration of a laser system in telephony, Perkin-Elmer Corp. was approached to provide the laser-audio link. A week and a half later, using off-the-shelf hardware, the system was in operation.

Also as a part of their coverage, the Museum, working with Dr. Edmund Land of the Polaroid Corp., planned to produce full color prints of the *Mariner*-collected photographs from JPL tapes.

● **Gas laser system**—Perkin-Elmer selected an unmodified Model 5200 helium-neon gas laser for its transmitter. Operating from a 5-watt input, voice communications were modulated and transmitted at 500 microwatts output using a wavelength of 6,328 Angstroms, well within the visible region of the spectrum.

The receiver, according to M. J. Fenton, P.E.'s manager of illumination systems, was the simplest possible, consisting of a telescope plus a photomultiplier. The latter employed an S-20 photocathode and a very fast automatic gain control (AGC) to limit scintillation.

During initial setup, a retroreflector was used to align the transmitter beam with the receiving telescope, Fenton said. The transmitter is located on the roof of the Museum of Science; the receiver near Station WLP, 10 miles away.

Gemini Trackers Score Firsts

Two important radar tracking "firsts" were achieved during the recent *Gemini 4* flight. RCA-built FPS-16 and FPQ-6 radars included in NASA's manned spaceflight network achieved consistent skin-tracking of the *Gemini* capsule throughout the flight and another RCA radar, the TPQ-18 located at Merritt Island, Fla., made detailed radar observations of the *Titan II* booster as it reentered the atmosphere and broke up into six separate pieces during the end of the booster's 32nd orbit.

NASA tracking engineers at Goddard Space Flight Center say the radar data throughout the flight was "excellent." While NASA has had some partial success in skin-tracking experiments earlier in the *Gemini* program while the *Titan II* second stage was still attached to the capsule, the *GT-4* flight marked the first time that an object as small as the solo *Gemini* capsule was tracked in this manner. Engineers at Goddard said the data was so accurate that it permitted shutdown of the *Gemini* on-board beacon for long periods without any loss of track. The gains in power conservation with beacon shutdown could be significant for future long duration manned missions, they report.

Tiros X in Good Orbit

The *Tiros X* weather satellite, launched July 1, has reached a near-perfect, Sun-synchronous orbit.

According to NASA officials, the satellite's orbit is "the best yet achieved in the weather satellite series." Apogee is 517 miles; perigee, 458 miles; and period, 100.6 min.

The satellite is programmed to take more than 400 pictures daily of the hurricane-breeding area between 70° N. and 30° S. latitude.

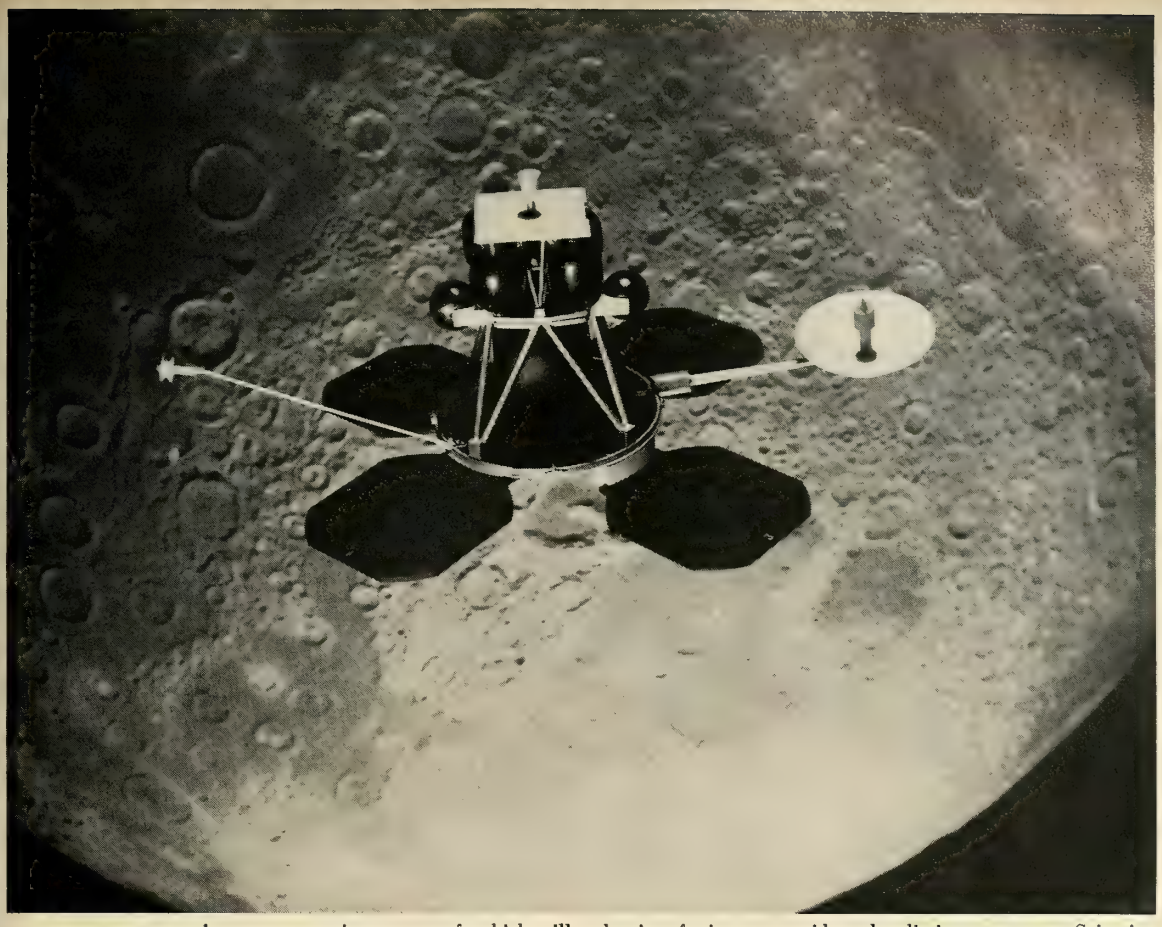
Magnetic Wind Tunnel

The French have successfully completed a series of aerodynamic measurements on a missile model magnetically suspended in a Mach-7 wind tunnel (see cover).

The 13-lb. experimental model, used to solve a re-entry problem, is the largest known to have been suspended in this manner. NASA centers, particularly Langley and Ames, have done some work on magnetically suspending very small models. Princeton and MIT have also looked into the matter but without any perceivable results.

The advantage of magnetic suspension stems from doing without the sting, or physical supporting mechanism, for the aerodynamic model. Without physical supports around the model, the air flow is more natural and consequently the aerodynamic coefficients can be more accurately found.

The French hypersonic wind-tunnel has a useful test-section of 1 foot in diameter and gives Mach-7 during a 20-second run.

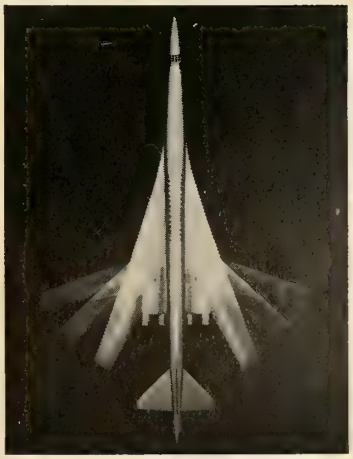


LUNAR ORBITER is camera-carrying spacecraft which will be launched into lunar orbit to photograph and transmit to earth pictures of large areas of moon's surface. Mission is to help locate best landing spot for astronauts, and to sense and report density of micrometeoroids and radiation near moon. Scientists will also track Orbiter to learn more about moon's gravity. Boeing is building 8 Orbiters for NASA, 3 for ground test, 5 for flight. First launch is scheduled next year at Cape Kennedy.

Capability has many faces at Boeing

BIG BLOW. Wind tunnel tests are used in air-to-ground missile studies. Boeing's vast missile, space booster and electronics experience in radar, guidance and penetration aids is helping to develop advanced attack missile system concept.

SUPERSONIC jetliner, under development by Boeing, could carry over 200 passengers across U.S. in two hours. Variable wing gives ideal sweep-back choices for supersonic and subsonic flight, plus straight wing for slow landings.



U.S. NAVY'S versatile new transport helicopter, UH-46A, built by Boeing's Vertol Division. UH-46A's replenish combat ships while underway (permitting maintenance of task force integrity), also perform search and rescue, personnel transfer, and other missions.

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Close Tracking of Mariner Continues

Occultation experiment pressed for vital trajectory plotting; photo results uncertain in early hours; no fields or particles

PASADENA, CALIF.—Pinpoint tracking of *Mariner IV* continues without a break for 10 days following its closest approach to Mars on July 14, to obtain the all-important trajectory plot from which measured deviations in predicted Droppler signals will indicate the atmospheric pressure and constituents.

Rated as important as the picture-taking test, the occultation experiment stretches the measurement capabilities of Jet Propulsion Laboratory's Deep Space Instrumentation Facility (DSIF) to their utmost, so that the minute perturbations in the spacecraft's transmitted signal due to the Martian atmosphere can be separated from the Doppler shift produced by the trajectory change at Mars.

By plotting the trajectory 10 days before and after encounter, DSIF hopes to be able to measure the spacecraft's velocity to an accuracy of 0.0015 meters per second.

● **Photo puzzle**—Planet detection signal by the wide-angle sensor was received at 7:55 p.m. EDT. Shortly afterward, engineering data indicated that the spacecraft was taking pictures that were changing in light intensity as *Mariner IV* swung toward the shadowed side of Mars.

Shortly thereafter, however, data from the tape recorder indicated that the system was running continuously, not stopping after each picture was taken as had been planned. The end of the tape signal came sooner than expected.

Because of this, engineers at JPL feared that some of the planned 20 pictures might be lost. Estimates of the loss ranged from 7 to 13 photos.

● **Dust-free**—NASA/JPL experimenters closely monitored the magnetic field and particle experiments during the encounter. No detections by these instruments—including the cosmic ray telescope, cosmic dust detector, trapped radiation detector, solar plasma probe, and magnetometer—were reported right up to the closest Martian approach.

Experimenters were hoping for enough interpretable data to provide a fairly complete initial survey of the shock front, magnetopause, magnetosphere, Van Allen belts, and any near-Mars dust concentrations.

One early result reported from the encounter was that Mars' magnetic field is less than several percent of the Earth's field. Analysis will look for a field down to 0.1 percent of Earth's field.

Cruise data from the cosmic dust detector has shown a marked change in the number and size distribution of dust particles at a distance of about 0.2 astronomical units (au) from Earth extending to about 0.06 au from Mars.

Leaving Earth, *Mariner* experienced about one dust impact every four days. In the region between 1.2 au and nearing the Martian orbit, impact frequency increased to about four impacts a day, and the number of small-sized particles decreased.

Overall intensity of dust impacts posed no hazard to the spacecraft. This led to puzzlement over earlier Soviet announcements that their spacecraft failed in two instances because of cosmic dust impact.

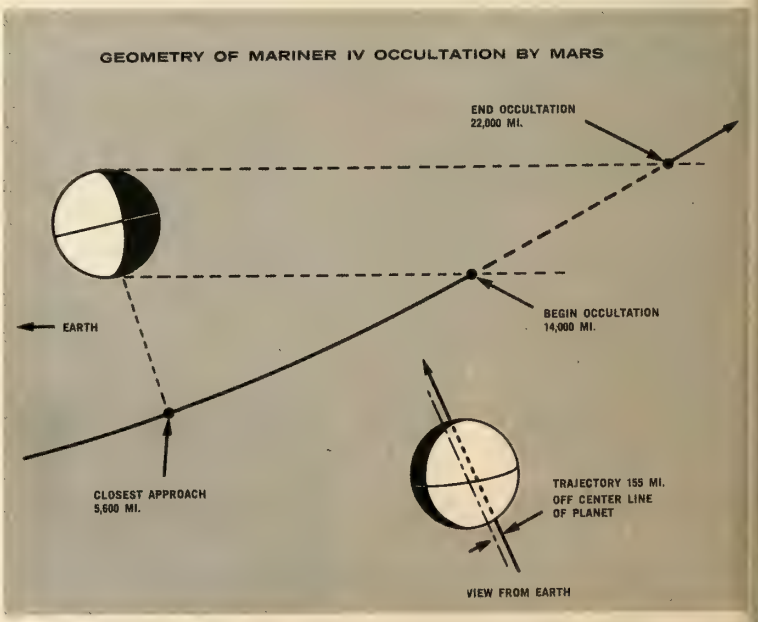
The experimenters believed preliminary results indicate no hazard to manned spaceflight from cosmic dust.

● **No immediate photos**—During the *Mariner IV* encounter, telemetry told investigators only that the 25-minute television photographic sequence, designed to obtain up to 22 pictures, was supposed to be taking place. Whether the spacecraft succeeded in obtaining any photos was not to be known until its tape recorder was played back, beginning 10 hours or more after completion of the encounter photo sequence.

A very small portion of each photograph will occupy the prime attention of the photo evaluation team, with the hope that it will contain information that, as one experimenter put it, "we can parlay into interpretation of the rest of what is seen in the pictures."

The experiment was designed to produce black and white photographs in pairs, one with a blue-green filter, the other with an orange-red filter, and with a small but all-important overlap of a few percent of the two frames. The overlap region is the only portion of the photographs providing the possibility of looking at the same object or Martian surface area under different filters.

This provides the capability of distinguishing color variation from brightness variation in order to obtain a better idea of the physical characteristics of Mars' surface. Information from the overlap area may provide clues to interpretation of the non-overlapping portions of the photos. The overlap was not designed to provide stereoscopic viewing, although investigators were ex-



pected to test whether this might help in interpretation.

The different colored regions of the planet have been interpreted by some observers as indicating the possibility of areas of vegetation, color and configuration of which change with the seasons. Other observers have preferred to interpret the difference in color as due to color variations in the Martian soil, possibly because of changes in moisture content.

● **Skin-deep observation**—Main purpose of the TV photo experiment is to aid in determining surface physical characteristics; however, prominent experts believed there was very little likelihood that an experiment of this nature could indicate whether vegetation exists on Mars.

For some who wonder about the possibility of "canals," however, it was pointed out that the expected 2-mile resolution, with distance of the photos ranging from 10,000 to 6,000 mi. from the surface, may enable determination of the gross characteristics of the linear features that have long puzzled observers and perhaps shed some light on the matter.

At the same time, it is pointed out that the best photos of Earth obtained with the *Tiros* satellites revealed no signs of human existence.

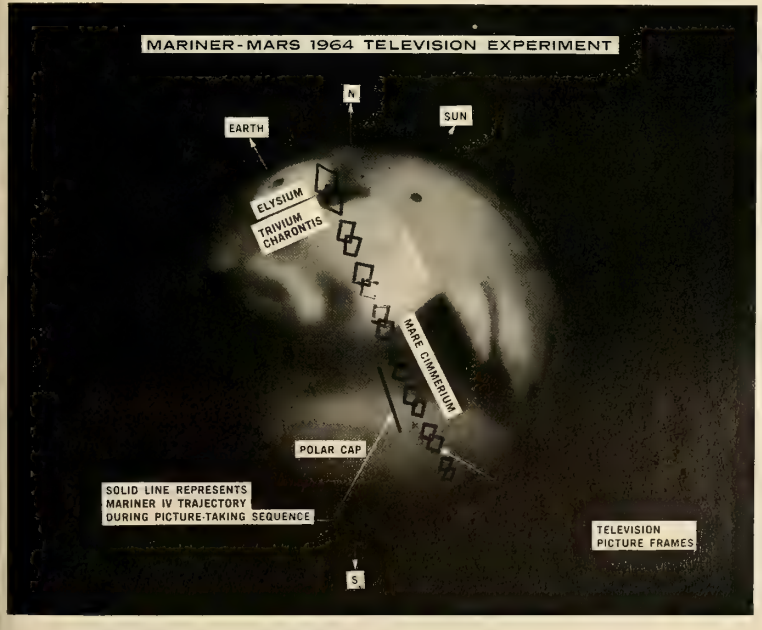
More conservative investigators have speculated that the linear features on Mars are cracks or ray systems resulting from meteoroid impacts. Some observers have noted that linear features are dark on Mars while those on the Moon are light in color. A theory drawn from this is that Martian ray systems might be dark because vegetation would concentrate in broken surface areas rather than elsewhere.

● **Filters will help gain detail**—Part of the reason for including filters in the *Mariner* TV system, whereas *Ranger* was equipped with none, is that Mars is expected to present a much smoother surface than the Moon and exhibits a great deal more coloration.

Investigators reported that Mars probably experiences fewer meteoric hits than the Moon. Also—apparently because it has winds and dust storms, possibly even precipitation—craters would be more rapidly filled in. A smoother Martian surface will make photo interpretation even more difficult, Dr. Robert B. Leighton, principal photo investigator, pointed out.

Leighton, whose past color photographs of Mars are well known, said broad objective of the experiment was to make a preliminary reconnaissance of Mars, viewing both light and dark spots as well as the terminator, the polar cap and the planet's limb. He was hopeful of obtaining photos of snow or frost in the polar region since reflectivity would be constant and therefore enable easier identification of slopes, distinguishing them from ordinary albedo variation.

With luck, Leighton said, a photograph of the planet's edge might be obtained, permitting surface height variations to be seen and revealing something about the atmosphere. However, he rated chances of obtaining such a picture at less than 50%.



Resolution of photographs would be about 30 times that with Earth-based observation, each consisting of 250,000 bits and closest photos 125 miles on a side.

● **Occulation tests also important**—The occulation experiment (M/R, July 12, p. 11) was rated equal in importance to the photographs since it was expected to determine characteristics of the atmosphere important to design of future entry capsules, including whether a parachute system could be used for softlanders.

As is the case with the photos experiment, the occulation data will require a very detailed analysis before any conclusions can be drawn. At the earliest, some idea of what was learned may be available 2 weeks following encounter.

Estimates of surface pressure vary widely, from 10 to 100 millibars, and a scale height is unknown. The experimenters estimated that if the surface pressure is 10 millibars, it is doubtful that ordinary drag retardation bodies and parachutes could be used. NASA designers were hoping for at least 40 millibars.

● **Other instrumentation**—The helium vapor magnetometer, designed to map the Martian magnetic field and its interaction with the interplanetary magnetic field, is located on the low-gain antenna mast to minimize the effect of the spacecraft's magnetic fields. Its support electronics are inside the spacecraft.

The principle used is to measure the amount of light from a helium lamp as it passes through a cell of excited helium gas. Before entering the cell the light is collimated and circularly polarized. Its intensity is measured by an infrared detector.

The magnetometer was manufactured by Texas Instruments, Inc. Its sensitivity is 0.5 gamma per axis; the dynamic range is ±360 gammas per axis.

The trapped radiation detector makes use of three Geiger-Mueller tubes and one silicon diode encased in thin nickel foil. Shielding permits low energy particles to enter only through a window at the end of each G-M tube: the first two detect protons with energies above 500 kev and electrons above 40 kev. The third detects protons above 900 kev and electrons above 70 kev. The solid-state detector detects protons in ranges from 500 kev to 8 Mev and from 900 kev to 5.5 Mev.

Mounted on top of the spacecraft bus, the experiment weighs about 2¼ lbs. and was conceived and developed at the State University of Iowa.

The three G-M detectors have their axes parallel to each other and at an angle 70 degrees away from the probe-Sun line. ■

Martin Aiming at Spacecraft Field

Denver division puts 100 top men to work on top-secret research effort to exploit 'synchronous corridor' potential raised by Titan III-C

by Donald L. Zylstra

THE MARTIN CO. last week partitioned off a sizable portion of its electronic manufacturing facility in Littleton, Colo., as a top-secret working area for more than 100 of its leading scientists and engineers. The move signaled the firm's determination to make a strong bid in additional areas of space technology.

The new Martin-Denver Division research effort, known internally as "Force XXIV," is a major company-funded move to enter the spacecraft field. Vehicles for exploiting the possibilities of the "synchronous corridor," an area in space at an altitude of 19,340 n. mi. directly over the Earth's equator, could be designed for multiple missions with payloads now possible.

I. Nevin Palley, executive director of technical operations for Martin-Denver, who will direct the efforts of the 100-man team drawn from every sector of the company, cites Martin's successful development of the *Titan* family of boosters as a factor giving his firm a significant leg up in spacecraft development. *Titan III-C* with its Transtage currently gives the United States the capability of inserting a 1,900-lb. payload into precise synchronous orbit.

"In the past, military men and U.S. scientists have been intrigued with the possibilities inherent in development of vehicles for operation in the synchronous corridor," Palley noted. "But until *Titan III-C* and its Transtage afforded the means to put nearly a ton into orbit at this altitude, discussion of synchronous corridor vehicles and their advantages remained largely academic. Now, for the first time, through technology developed by industry and the Air Force, the U.S. has the ability to orbit substantial unmanned synchronous payloads. Our company is investing a large segment of its talent and resources in a serious bid to develop the vehicles that can take advantage of this new capability."

● **Military aspect**—In addition to its possibilities for new business, Palley sees the move as extremely important to the nation's defense establishment, both strategically and tactically. "It will be our intent to discover and implement the technology that will prompt the U.S. to exploit its chance to be first in the synchronous corridor," Palley said.

"If the nation moves with deliberate speed in this area, we're convinced we won't have to play catch-up, as has been the case in other aspects of our race with the Soviet Union. Scrambling to catch up has proved both expensive and wasteful and the nation has an excellent opportunity to avoid this posture in the synchronous corridor if we act promptly."

Palley and his associates, along with many top military strategists, are convinced that domination of the corridor is of greater long-term practical importance to the U.S. than any aspect of the lunar program. Most military strategists believe the corridor, rather than the Moon, will be the military and political leverage point of the future.

Given the opportunity of establishing a line-of-sight, real-time relationship, with men in strategically placed ground stations, strategists believe synchronous satellites could dominate military conflicts as the "high ground" of the future. With the line-of-sight advantage afforded by vehicles in synchronous orbit, plus real-time communications, the manned part of such military systems can be on Earth, leaving a maximum payload for instruments without imposing weight penalties for life-support systems.

As presently conceived, a precise equatorial orbit would not be necessary for synchronous corridor vehicles, since their military missions might be benefitted by limited orbital transfer capabilities, or a figure-eight deviation permitting diversions 100 miles or more north or south of the equatorial plane.

Presently, the U.S. has no navigation system in missiles or aircraft guaranteed to survive a nuclear attack. With a system of synchronous multi-purpose satellites, navigation facilities in orbit would survive an initial nuclear exchange. Merely as passive, fixed navigational check points, synchronous satellites have an obvious advantage. As an active system its contribution would be even greater.

Even the argument that such a system would be a "sitting duck" for enemy destruction in a shooting war poses little concern for the strategists. They note that launches of systems to kill or intercept vehicles in synchronous orbit would require on the order of 12 hours. Probably this could be reduced to six hours at the very minimum. In a hot war, this interval for watching an enemy attempting to eliminate a U.S. synchronous system would afford one of the best possible warnings of his hostile intent.

Martin technologists regard the synchronous corridor as one of the most practical, sensible areas in which the aerospace industry can move in the immediate future. The widespread military attitude which has been prevalent—saying in effect that "space is fun, but ballistic missiles are our real mission"—is rapidly being revised as military men contemplate the systems that have become a near-term prospect with the *Titan III* booster system.

● **Further dividends**—Martin engineers note that their Transtage vehicle, with its present design life of 6.5 hours is limited only by the life of its batteries. Orbital life of up to a year is regarded as an early possibility for an improved Transtage, with the development of satisfactory solar power cells or an onboard nuclear power supply.

Noting that virtually an entire hemisphere of the Earth is visible in the 17-degree angle of view affored by a single satellite in synchronous orbit, Palley cited such a vehicle's advantages for missions involving weather, navigation, surveillance and command-and-control functions. Strategically and tactically the synchronous orbit vehicle offers military advantages far outstripping the Panama Canal and the DEW line of earlier eras, he said.

Biggest tactical advantage of a synchronous-orbit military vehicle, with real-time data delivery and response to commands from Earth, would be immediate freedom from present frustrating dependence on massive, complex, exasperatingly slow data-retrieval.

Washington sources indicate the Space Systems Division of Air Force Systems Command is about to issue requests for proposals for a large unmanned multi-mission military satellite. Studies of the concept, dubbed 244, will investigate the cost/effectiveness of a number of military functions in one vehicle.

Confronted with the possibilities made real by the advent of *Titan III*, military chiefs and engineers are now wondering why there has ever been serious concern over a dearth of military payloads for the newest Air Force booster. ■

GT-7 Crew Wants 'Shirtsleeve' Flight

Suitless mission, if approved, would be first for U.S.; Mathews reveals details of computer failure, other data from Gemini 4

THE *GEMINI 7* flight crew of Frank Borman and James Lovell is pushing for approval of a "shirtsleeve" environment during their 14-day flight now set for early next year.

At their request, the crew systems division at NASA's Manned Spacecraft Center is designing a prototype coverall containing one light pressure bladder for ventilation.

Another group is looking into the danger of the spacecraft cabin being punctured by meteoroids during such a flight. Another is trying to determine if astronauts could survive in a reduced cabin-pressure atmosphere of two psia wearing emergency oxygen masks should they initiate an immediate retrofire reentry.

In a shirtsleeve environment, the astronauts would not wear their space suits, but would rely on the spacecraft life support system for oxygen.

If approved, this would mark another first for the U.S. space program. The Soviet Union, however, has already made such a flight in the *Voskhod* spacecraft.

The possibility of this switch in the *Gemini 7* flight was learned as the Manned Spacecraft Center made its report on the four-day *Gemini 4* mission.

● **GT-4 findings**—The report revealed that damage to the memory software of the onboard spacecraft computer was probably caused by the loss of the computer's standby power supply.

Another conclusion was that the attempt to rendezvous with the *Titan II* second stage has definitely established that station-keeping with another orbiting object by visual means must be restricted to very short ranges with relatively no difference in speed between the two vehicles. *Gemini* project manager Charles W. Mathews said this was learned by reconstructing the trajectories flown by the spacecraft and the *Titan II* stage.

● **Computer failure**—The inability to turn off power to the computer now appears to be the first of chain of events which led to its eventual failure, Mathews said.

After the computer failed to turn off with its on/off switch, the crew was instructed to halt power to the computer by turning off the inertial guidance system (IGS) power supply. This illuminated the computer malfunction light momentarily and the crew returned IGS power to normal.

"At this particular time, as near as we can determine, the system was in good operating condition," Mathews said. "But we were not sure of spacecraft power consumption up to that time and we looked at possibilities for turning it off."

An auxiliary battery power supply within the computer automatically comes on line whenever IGS power is interrupted so that the computer will continue to operate, he explained. This supply must maintain a constant 19 volts for reliable computer operation.

"The auxiliary power supply kept the computer running during these clicks on and off. At one time, however, the IGS was off a little too long and the load on the auxiliary power supply caused its battery to drain to a low voltage," he said. This scrambled the information in the memory.

"At that time, we had essentially had it," Mathews said.

Powering down the computer by any means involves an ordered sequence of automatic events, he said. One of these is a recycling within the computer program. The scrambled memory, however, prevented the computer from recycling—and in fact locked it in a random loop.

The altered memory made the computer unusable for the remainder of the flight. Except for the altered memory, the computer was physically "okay," Mathews said.

● **Elusive booster**—In discussing the station-keeping attempt, Mathews said that while separating from the booster, the spacecraft aft thrusters added a velocity of two to three feet per second to the booster when they fired downward. This had not been expected. Thus later, even though command pilot James McDivitt fired his thrusters for the planned period to keep the booster in sight, the spacecraft and the stage continued to move apart.

"In fact, he was separating one and one-half to two fps from the second stage," Mathews said.

This separation velocity gradually increased in magnitude as a function of orbital mechanics.

McDivitt was required to perform a scheduled platform alignment, and this distracted him from the station-keeping task, Mathews said. "We wanted him to align the platform early in the event an abort situation developed before he completed the first orbit."

Midway through the alignment, however, McDivitt did take a look at the booster. He was surprised to find that it had dropped much lower than he had expected. He made a brief correction at the time by thrusting down at the booster, Mathews said.

Just before he entered the night side of the orbit, 35 min. after separation, McDivitt made a substantial "burn" toward the booster and started the spacecraft moving down to the booster's altitude.

"A rebuild of the trajectory shows that he was closing on the stage and at that time was within three-tenths of a mile," Mathews explained.

McDivitt had a pretty good feel for the situation, Mathews said, before the spacecraft entered the night side. But from that point on, additional maneuvering of the spacecraft did not improve his position and the long-term effects of orbital mechanics moved the spacecraft away from the *Titan II* rocket stage. When he came out on the day side, the booster was three miles below.

"The main problem was that we didn't firmly establish a closing rate on the vehicle right from the start," Mathews said. The pilot was occupied with other tasks and could not keep track of the booster.

● **Thruster failed**—During re-entry, a pitch thruster in the re-entry control system (RCS) failed to fire, but this was not detected by the crew because there is so much backup available on the two rings of thrusters that only a multiple thruster failure would have noticeable effect on the spacecraft. The failure was traced to a broken wire at a crimp connection.

Mathews said the hatch closing mechanism on the spacecraft, which caused trouble on *GT-4*, has been completely redesigned.

Despite the redesign, NASA has already announced that there will be no extravehicular activity (EVA) during the next three flights. *GT-6*, scheduled for October, will be a two-day mission, including the first attempt to rendezvous with the *Agena* target vehicle. ■

AIAA Stressing Better Understanding

Special Preview Report on San Francisco meeting: officials hope for improved inter-communication; 4,000-10,000 may attend

SAN FRANCISCO—Keynote of the second annual meeting of the American Institute of Aeronautics and Astronautics, opening its four-day agenda at the Civic Center here on July 26, is the advancement of mutual understanding among the many advanced technological areas involved in the national aerospace endeavor.

Up for intensive discussion are spaceflight plans of the National Aeronautics and Space Administration and the Dept. of Defense through the next decade, the impact of missile/space technology in the United States and abroad during the next 20 years, the outlook for the projected Supersonic Transport and other aircraft, and probable developments in such related fields as underwater electronics and propulsion.

More than 350 technical papers and lectures are slated for the meeting, which will be attended by some 4,000-10,000 scientists and engineers.

Because the field has expanded so quickly and each branch of technology has intensified its preoccupation with its particular problems, communication has suffered. AIAA officials are hopeful that, beginning with this year's meeting, the information painstakingly developed in all areas will be made available in a form generally understandable to all participants.

The effort to improve communication was part of the motivation behind the formation of AIAA—a merger of the Institute of Aerospace Sciences and the American Rocket Society—discussion of which began three and a half years ago (see page 56).

With a view toward further cohesion, Institute officials have already begun consideration of next year's annual meeting, to be held in Boston. A panel of six leading industry and government figures, chaired by Arthur Kantrowitz of Avco Corp., is scheduled to meet on the evening of July 28 to begin work on a plan for the 1966 conference.

Also serving on the committee are Herbert Friedman, head of the Naval Research Laboratory's Atmosphere and Astrophysics Div.; Albert C. Hall, deputy director for space, Directorate of Defense Research and Engineering; George Schairer, Boeing Co. vice president; Ernst Stuhlinger, of NASA's Electronics Research Center.

After the master plan is drawn up, the AIAA's 36 technical committees will set about fleshing in the details of the Boston agenda.

At next week's San Francisco meeting, exhibits will be open to the public on Thursday evening, but otherwise will be reserved for participants.

Attendance is expected to total somewhere between 4,000 and 10,000, depending on how many drop in. Last year's meeting in Washington drew about 4,400, 1900 of whom visited only the exhibits. There will be a minimum of international participation, and no Soviet attendance whatever.

● **Key panel**—Highlight of the meeting is expected to be the final session Thursday afternoon, a panel discussion entitled "Aeronautics and Astronautics, 1985," which actually will attempt to forecast beyond that year.

The select panel will be chaired by Abe M. Zarem, president of Electro-Optical Systems. Other members are Simon Ramo, vice chairman of TRW, speaking on space and the automated society; Edward H. Heinemann, vice president-engineering and program development, General Dynamics, on aircraft in 1985; Herbert Friedman of Naval Research Laboratory, on space science in 1985; Arthur Kantrowitz of Avco, on military potentialities; and Dr. Wernher von Braun, director of Marshall Space Flight Center, on interplanetary exploration in 1985.

● **Other events**—Also featured on the program are:

—A luncheon speech on Monday by Daniel J. Haughton, president of Lockheed Aircraft Corp., on "Your Role in the New Environment."

—Panel on "The Future in Aircraft Design" Monday evening, moderated by David Anderton, MISSILES AND ROCKETS contributing editor. Panelists are W. E. Gasich, Northrop Corp.'s Norair div.; John Swihart, Boeing Co.; Larry Mead, Grumman Aircraft Engineering Corp.; and Charles W. Harper, NASA Headquarters' Aeronautics div.

—Luncheon Tuesday at which Bernard M. Oliver, vice president of Hewlett-Packard Corp., speaks on "What's Ahead in Radio Astronomy."

—Von Karman Lecture Tuesday evening by Dr. Raymond Bisplinghoff, who is leaving his post as NASA associate administrator for advanced research and technology to become president of Case Institute of Technology.

—Luncheon speech Wednesday by Winston Kock, director of NASA's Electronics Research Center.

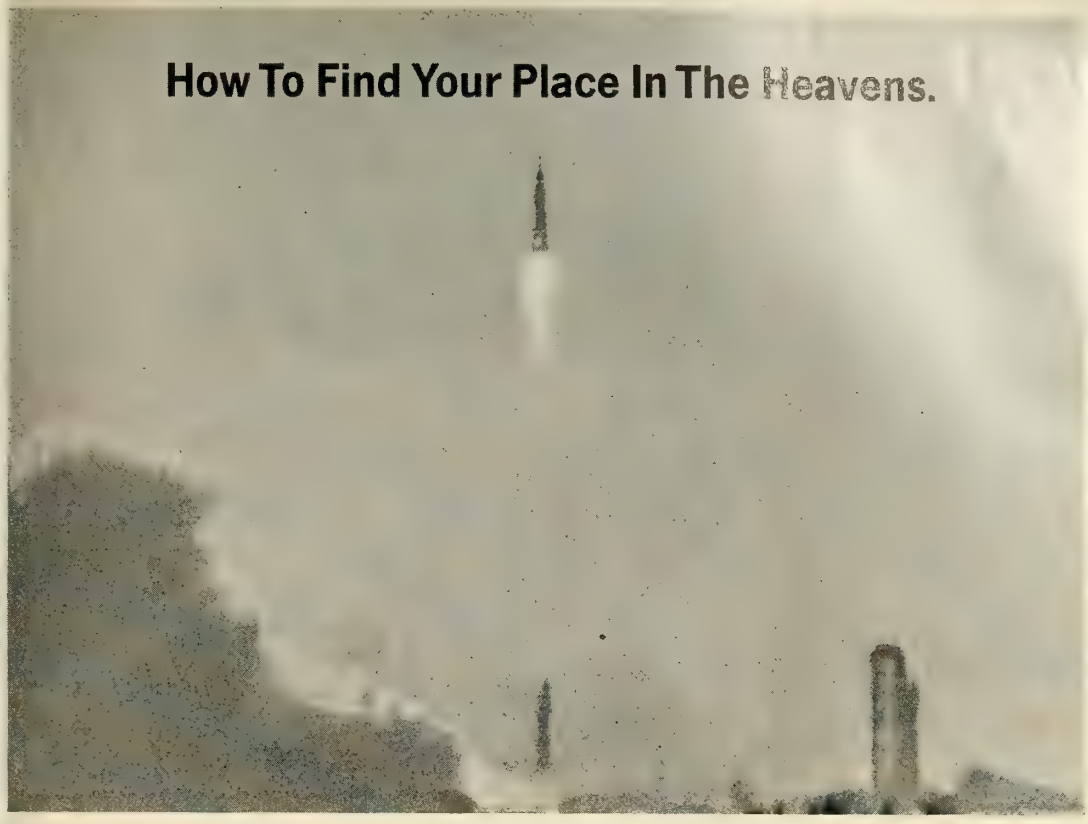
—Latest Events Session Wednesday evening at which William Kirhofer of Jet Propulsion Laboratory will discuss *Ranger* trajectory analyses, Dr. William Pickering, JPL director, will detail results of the July 14 *Mariner* Mars flyby, and Dr. George Mueller, NASA associate administrator for manned space flight, will describe results of *Gemini* flights to date.

—Panel discussion Thursday morning on "Management Implications of the National Space Program." Chairman is R. L. Johnson, vice president and director of manned spacecraft programs at Douglas Aircraft Co.'s Missile and Space Systems Div. Participants and their topics, are: De Marquis D. Wyatt, NASA deputy associate administrator for programming, "The NASA Space Program, 1965-1975"; Dr. Albert C. Hall, DDR&E, "The Military Space Program , 1965-1975"; Maj. Gen. Marvin C. Demler, commander, AF Research & Technology Div., "New Technology Challenges"; Ronald Smelt, vice president and chief scientist, Lockheed Aircraft Corp., "Management and Focusing of In-house R&D, 1965-1975"; Hilliard W. Paige, vice president and general manager, General Electric Co's. Missile & Space div., "Facilites Status and Outlook, 1965-1975"; Richard B. Morrison, aeronautics professor, University of Michigan, "Skill and Educational Requirements"; and Robert H. Charles, Assistant Secretary of the Air Force, "Government Procurement Practice." ■

(*Report continues on p. 47*)

PREVIEW OF SECOND annual meeting continues, beginning on page 47, with detailed and updated program of events, a list of exhibitors' booths and accompanying map, a map of San Francisco, and a history of the American Institute of Aeronautics and Astronautics.

How To Find Your Place In The Heavens.



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AERODYNAMICS — Perform analyses of aerodynamic characteristics effected by airplane control systems and stability augmentation systems. Experience in systems analysis and working knowledge of analog computers.

STRUCTURAL DYNAMICS — Analysis of complex structure vibration, airframe loads and response, and application of probability theory to structural design criteria.

LOADS ANALYSIS — Perform aeroelastic loads analysis, coordinate loads testing and establish requirements for extensive design loads investigations.

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HYDRAULIC SYSTEMS — Analysis, testing and design of hydraulic systems. Experience with system pumping, control components, and heat transfer of high pressure systems (knowledge of current techniques used in hydraulic servo valves for powered flight controls).

ENVIRONMENTAL CONTROL — Heat transfer analysis with application to air cycle conditioning of jet aircraft. Emphasis upon avionic equipment conditioning to develop new environmental conditioning concepts.

ANTENNA SYSTEMS — Design, performance, evaluation, and analysis of radome, antenna, and RF transmission systems. Experience in antenna,radome, or wave propagation.

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House Group Will Recommend Changes In GAO Defense Contract Audit Practices

by Heather M. David

THE HOUSE MILITARY Operations subcommittee will issue recommendations to modify some practices of the General Accounting Office in its audit of defense activities.

One of the sure results of the month-long probe of GAO's defense contract audit activities (M/R, June 7, p. 10) is a recommendation by the committee to set a statute of limitations on how long the Government may take action against a contractor after a contract has been completed. This has been one of biggest concerns of the subcommittee, as indicated by Chairman Chet Holifield (D-Calif.), who stated that "remedy long delayed is in effect denied or certainly punitive."

In some cases, it was brought out during the hearings, payment is suspended from a contractor's account while the Department of Justice is considering a GAO report and making a decision whether or not to take action against the contractor, a process which may take years. During this time, the contractor may not appeal to the Court of Claims for relief, since there is no action to appeal.

● **A few concessions**—GAO indicated to the subcommittee, in closing day of testimony, that it would agree to some changes in its procedures, but that basically, some real differences still exist between the Office and the Department of Defense and its contractors.

In addition to the statute of limitations, which action GAO pointed out the Congress would have to initiate since it would require the cooperation of the Justice Department, Acting Comptroller General Frank Weitzel conceded that some modifications could be made.

A great deal of discussion revolved around the publicity given to GAO reports or "blue books" in which the Office summarizes its case against the service or contractor, and that party's response. While much damage was laid to the sensational press, it also was pointed out that the titles given these reports, and language contained in the summary letters, is often colorful and sometimes a bit flamboyant.

It was suggested by committee staff that GAO simply send the report, with a title that does not attempt to influence a conclusion, to the Congress, and let the case be judged on its own merits. Weitzel said that GAO was working on the problem of adjectives used, in order to "direct more effort to becoming more accurate without shading."

Another point that Weitzel agreed could be changed is the use of names of contracting officers in the reports, since it tends to indict an individual, Holifield pointed out, for a situation which may not be his doing or may simply be a difference of opinion between GAO and the parties involved.

● **Question mark**—One of Weitzel's statements, regarding the basis on which GAO decides to take up cases, was a point of some debate in the committee. According to the Acting Comptroller General, GAO will not bring up a case claiming an undue profit and asking for a refund if the contractor gave full and accurate pricing and cost information at the time of the transaction. This was contrary to the impression received from some contractor witnesses.

● **What's in a name**—Both members of the committee and GAO witnesses agreed that the title General Accounting Office no longer describes the mission of the office, which is no longer charged with responsibility for the Government's auditing activities. Weitzel indicated that this was the original concept at the time the name was chosen, but it would be difficult to change the name now.

Weitzel told the committee that he was "concerned over what seem to us to be basic objections on the part of some defense contractors and their associations toward our efforts to fulfill our statutory duties and responsibilities." He cited a number of legal passages that are interpreted as giving broad powers to the GAO, such as one which says "the Comptroller General shall give due regard to generally accepted principles of auditing, including consideration of the effectiveness of accounting organizations and systems, internal audit and control, and related administrative practices of the respective agencies."

Weitzel continued by stating his feeling that "If we are to carry out our duties as we understand them to have been intended by the Congress, it is impossible not to enter the judgment area. However, we think we have discreetly exercised our authority and responsibility with respect to management matters involving the exercise of judgement."

One difference of judgment between DOD and GAO, Weitzel said, is on the question of voluntary refunds which DOD does not seek when there is no misrepresentation or overreaching on the part of the contractor.

Weitzel said that DOD's policy of not requesting refunds in the situation where the contractor has given DOD a "take-it-or-leave-it" choice, can be argued. GAO feels refunds can be sought when prices are established under a letter contract after substantial completion of the work wherein the Government has no alternative but to continue the contract.

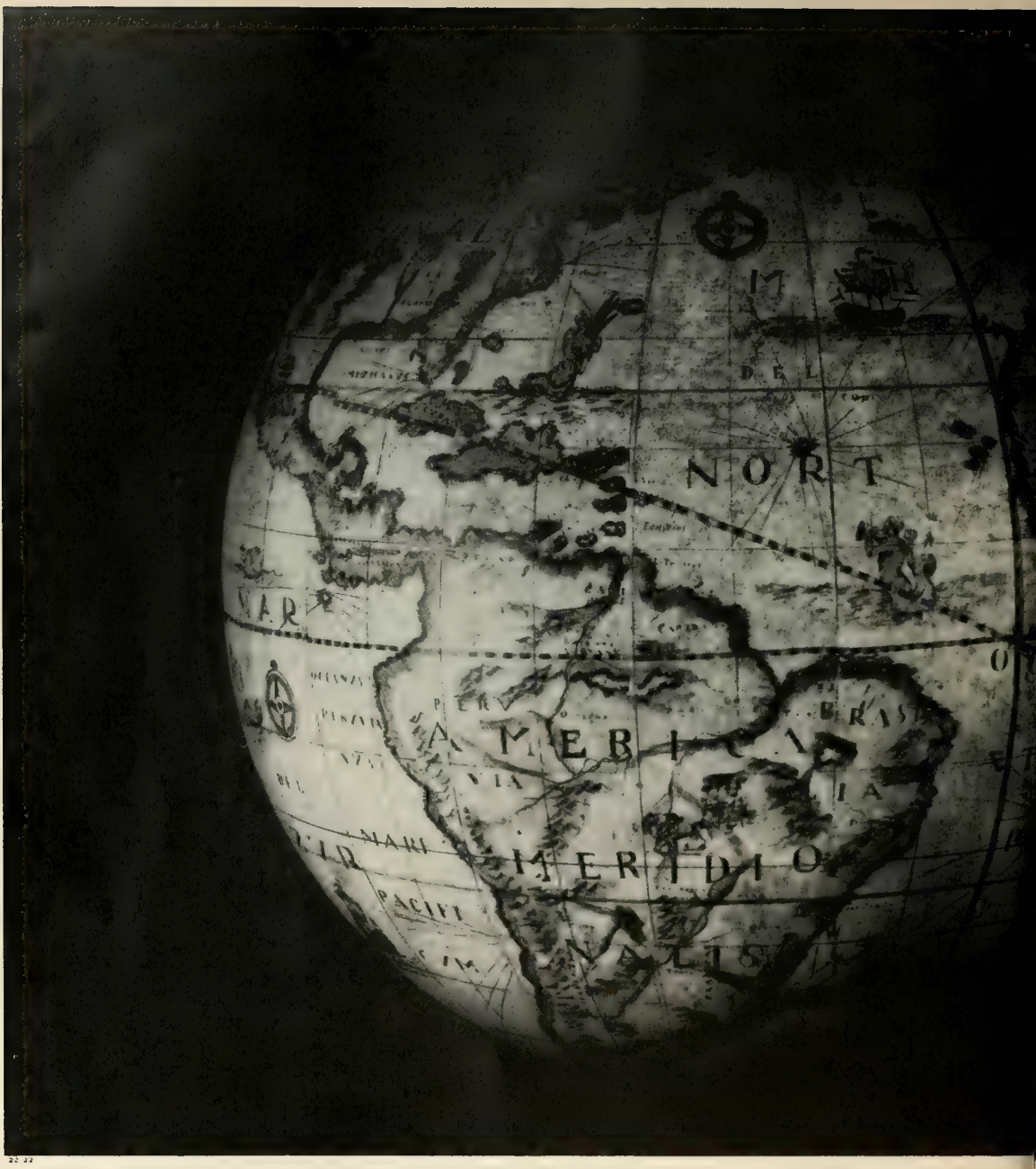
Another area of judgment dispute centers over the GAO's charges that in some cases there has been inadequate price competition on negotiated contracts. Weitzel said GAO feels it its duty to report on cases where the similarity of prices quoted and other conditions make it highly doubtful that prices have been subject to the forces of true competition.

Another case, he said, would be that in which two sources may have been solicited but both sources were assured of getting a substantial amount of the total procurement, "thereby creating little incentive to the contractor to quote its best price in order to obtain the business."

Answering charges that GAO claims 20/20 hindsight, Weitzel said that the office goes to great lengths to determine the circumstances and conditions existing at the time of negotiations. "We know of no instance in which we have taken the position that pricing information that may have become available subsequently should have influenced the price negotiation if it could not have been known to the parties at the time of the negotiation."

Weitzel stated that GAO reports are confined to commenting on actions that are "generally the result of failure to comply with applicable legislation, regulations, or other procedures that any prudent businessman would follow in doing business for himself." He noted that GAO would be remiss if it failed to report on such matters as overpricing of contracts "simply because certain individuals might overreact to fear of criticism."

Although open hearings have been concluded, the subcommittee has left the record open for further conferences between witnesses and committee staff members. ■



When LEM men go down to the moon in ships.

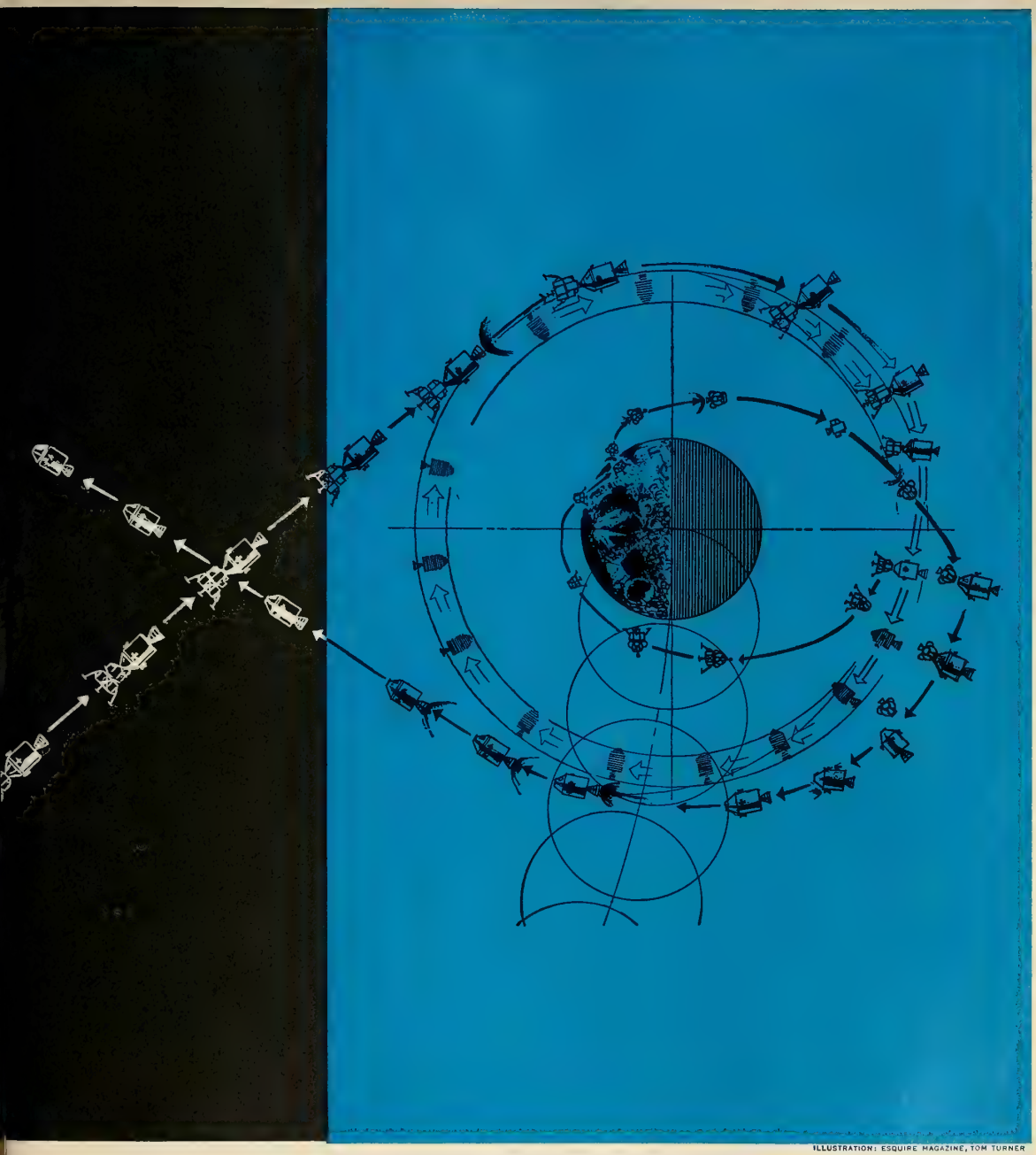


ILLUSTRATION: ESQUIRE MAGAZINE, TOM TURNER

TRW will help them get back. By 1970 two Apollonauts will descend onto the moon in their Lunar Excursion Module (LEM). A TRW advanced propulsion system will land them feather-soft. They will explore the lunar surface, then prepare for the long journey home. After lunar blast-off they will rendezvous with their return vehicle holding in orbit 80 miles out. During this lunar phase a lightweight TRW-built "strapdown" inertial guidance system will enhance their safety. These major Apollo tasks have been assigned to TRW Space Technology Laboratories by the Grumman Aircraft Engineering Corporation. TRW will also provide mission planning and analysis for Project Apollo, as it has done for the Mercury and Gemini programs.

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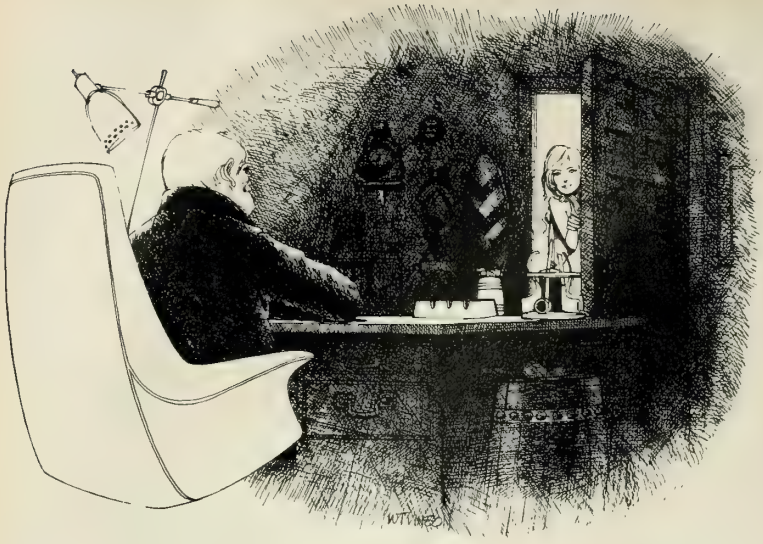


Merton-Smith & the Well-Made Widget

The one lone light of the desk lamp shone down on the tousled, red hair of Dr. Burton Merton-Smith and the myriads of papers that lay before him. Beyond the window of the den in his home stretched the midnight lights of the San Gabriel Valley, but Merton-Smith was seemingly unaware of them.

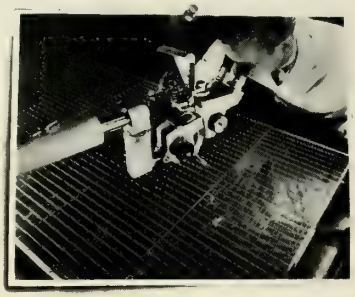
"Damn," he whispered, crushing the paper he had been working on and throwing it artfully into a filling wastepaper basket. "If I use a double compound-reflective system for thermal imaging..."

A shaft of light broke through the opening den door. She was marvelous to behold as she stood peeking into the semi-dark room, soft and warm and recent sleep relaxing her perfect face. It was Merton-Smith's wife, Carol, her hair hanging in gentle swirls about her shoulders. The light shone through her full length peignoir and Merton-Smith smiled remembering, suddenly, the two of them in that little chalet overlooking Lake Como.

"It's two o'clock, dear," she said. "Time for beddy bye."

"Yacccccchhhhh," he roared. "I assume you mean that it is time to retire. Well, it's not. It's time to figure out this problem."

"Can I get you something," she asked. He raised his eyebrow. "I mean a beer or something," she rejoined.



"Is there any Cordon Bleu left?" he asked.

She returned in a moment with two huge snifters with just a splash of cognac covering the bottom of each. She gave him his and sat with hers in his leather easy chair in the corner of the room.

He turned, cradling the glass in his hands, and looked out the picture window.

"Science is a plague on the mind. Those things are out there and no man, not even a million men working in concert, will ever find them all out. One can theorize, dream, even reduce theory to numbers and plans. That is the wildness and that is the witchcraft. But then the theory has to be implemented. What the guy on the other end of the tube wants is a piece of hardware. If we were stamping out beer cans, that's one thing. But when you start talking about manufacturing in very exotic fields with tough, tough, tough problems, you're really not talking about manufacturing. You're talking about another type of science... the science of precision manufacturing.

"The way Electro-Optical Systems goes about this precise science never ceases to be a source of constant amazement to me. It's as though the Plantagenet court jeweler could turn out a thousand ruby rings a day all with equal beauty and quality. It's surgery and watchmaking and jewelry and art combined."

"I'll take three," she said sleepily.

"Take a solar power system, for instance. The panels are pure art. If a mosaicist could put his funny little tiles together with the accuracy we put solar cells together, he would go down in history as a genius. For instance. Take those Ranger and Mariner power system jobs. With volume production techniques, we put together 30,000 solar cells on 22 panels with fantastic tolerances. On Ranger, JPL called for an 86 watt output and we gave them 105 plus or minus about one watt.

"Meanwhile, back here on earth, EOS is the major supplier of thousands of metal tank searchlight mirrors meeting rigid Army specifications. Then there's transducers for Apollo and LEM. And signal conditioning equipment. And electronic assemblies for Xerox. Sort of from zero-G to Xerocopy."

He took another long sip and sighed.

"And I haven't even mentioned QA. That's Quality Assurance, my dear. Take Mariner for instance—maintaining power for over 200 days as compared to only three days for Ranger. That's some doing. We like to think of ourselves as famous for advanced technology. Actually, what it boils down to is translating technology into meaningful devices and systems. Not just thinking about widgets, but getting hardware out the back door. Bet we could make anything in the world. As long as it's complex enough."

He turned around only to see Carol sound asleep, her legs curled beneath her, her head on the arm of the chair. He rose and gently roused her with a kiss on the cheek.

"Mmmmmm," she muttered. "Solar what?"

"Beddy bye," he said.

EOS

Dr. Burton Merton-Smith will be happy to exchange resumes with you. You send yours to him. He'll send his to you. Fields of interest: energy conversion, space propulsion, space probes, laser technology, imaging devices, optical systems and instruments, and information handling. EOS is an equal opportunity employer.

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Technical Countdown

ELECTRONICS

SIGS May Fly at Last

The Simplified Inertial Guidance System (SIGS) developed for the Navy by Norden Div. of United Aircraft Corp., may at last have a chance to fly. Scheduled for flight testing (open-loop) aboard a *Sergeant* missile on July 14 at White Sands Missile Range, the test system had undergone repeated flight cancellation since last March. Sperry-Utah Div., *Sergeant* prime contractor, has testing responsibility. A DOD spokesman last week stated that SIGS in production would cost ". . . under $20,000." Developers, however, still believe they can meet the Navy's need for a lower cost ($10,000 to $12,000), simplified, relatively accurate (under three mils) inertial system. The Army reportedly has shown considerable interest in SIGS development, possibly because its *Lance* missile has demonstrated an accuracy of no better than 5 mils.

New ARM and Electro-Optical Seeker Facility

Anticipating greater emphasis in the future on electro-optical systems, Martin Co.'s Orlando Div. is building a unique $2-million guidance system test facility. It will include a large microwave anechoic chamber for testing radiation-homing sensors, a computer-controlled pilot display center and an electro-optical sensor test facility. The latter will employ massive (40 x 40 ft.) terrain scale models to simulate real-time "missile" approaches to a target area at velocities of up to 30,000 fps. Terrain models will be moved toward the seeker for range control. The seeker itself will be mounted on a nested gimbal assembly installed on a large transport, thus providing roll, pitch, yaw and four linear degrees of motion (vertical and lateral). The facility, according to Martin, will permit realistic testing for the development of correlation techniques and laser, TV and radiation sensors.

PROPULSION

Gun Launched Probes at White Sands

Use of an 8-in. gun to launch high-altitude test probes is beginning to prove successful at White Sands Missile Range. The intention is to provide a cheap vehicle for sounding the atmosphere at 200,000 ft. and higher. Initial problems arose because of failure to track the vehicle at launch, due to extremely high muzzle velocity. In a recent launch, however, radar tracking was achieved and the payload, slowed by a metallized parachute, was recovered.

ADVANCED MATERIALS

Blast Tests on Missiles Slated

A 500-ft. extension, hardened to withstand the blast of chemical explosives, is expected to be operational on the Holloman AFB, N.M., rocket test track this fall. First tests on over-pressure effects on a missile will be carried out for the Navy. Later the extension will be used for Army and Air Force experimental work.

SPACE MEDICINE

Cuffs Prevent Weightlessness Effects

Cuff tourniquets applied to the extremities as protection against symptoms degradation of the cardiovascular system during simulated weightlessness were tested in water immersion studies at the Immobilization Study Unit of the Texas Institute for Rehabilitation and Research, Houston, under a NASA contract. It was discovered that in four subjects the marked blood pressure changes, fainting and other symptoms that occurred in tilt-table tests following 6 hours of water immersion were reduced considerably if the subjects wore cuff-tourniquets inflated in 1-minute-on, 1-minute-off cycles during the immersion.

Chinchilla Proposed for Space Research

Use of the chinchilla as a space research animal is being suggested by Dr. Eugene Rubacky, director of Drug Detection and Development Organization, Inc., in Washington, D.C. Rubacky, who has been closely connected with chinchilla research for a number of years, says that the animals are ideal for studying weightlessness, motion sickness and vibration in space vehicles. Besides their ability to survive without any food or water for as long as 32 days, they have large inner ears very similar to those of humans and are readily accessible for surgical examination; are subject to a number of human diseases; have high cholesterol values similar to humans; and are being used increasingly for a number of reasons already for ground-based radiation studies. Costs to researchers would be low, Rubacky said, because many are available each year with pelts unacceptable to the fur industry but otherwise in perfect health.

LIFE SUPPORT

High-Altitude Analyzer Developed

Researchers at the School of Aerospace Medicine's Physiology Branch have developed a method in which gas chromatography may be used to analyze respiratory gases at high altitudes. The technique eliminates a problem of contamination of the sample which often occurs when it must be brought to ground level. A commercial chromatograph was modified by the group, in such a manner that once the sample is taken, the investigator can descend to a lower altitude, decreasing the chance of decompression sickness from prolonged exposure.

Instant Oxygen Separator Shown

An experimental device that separates oxygen from all other constituents of air in a process called electrowinning has been demonstrated by Allis-Chalmers. The device, part of the company's program to exploit benefits of advanced fuel cell technology, can be plugged into a standard 110-volt outlet. Designed for use by pilots at high altitude, the unit is only slightly larger than an attaché case.

The only way to grasp the impact of General Electric's role on the Apollo Program is to work here.

The Apollo Support Department is working on the frontiers of reliability, integration and checkout for the NASA Apollo mission. Reliability and quality engineers use mission models to pinpoint critical equipments and sequences in the lunar mission, and simulate entire equipments before they're built to make sure they'll work. Extensions in the reliability art are the order of the day.

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Engineers—GSE Requirements	BSEE/ME/IE/Physics	Houston, Texas
Engineers—Parts Reliability	BSEE/ME/Physics	Cocoa Beach, Fla.
Electrical Engineers	BSEE	Cocoa Beach, Fla.
Engineers—Electrical Systems Test	BSEE/Physics	Cocoa Beach, Fla.
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Please write, in full confidence, including salary requirements to: Mr. D. D. Smith, Professional Placement, General Electric Co., Apollo Support Dept., Room 1111-D, Box 2500, Daytona Beach, Fla. 32015.

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(see also the other General Electric Missile & Space Division ad on pages 52 & 53.)

German Industry Hungry for Funding

Spokesmen say big increase is needed to provide efficient program and bolster nation's ability to compete internationally

by Michael Getler

BONN, WEST GERMANY—Many European observers believe that it is only a matter of time before the steady expansion of the West German economy, combined with the German tradition of advanced technology, will make this nation the leading—if not dominant—aerospace force on the Continent.

Oddly enough, the certainty with which outsiders view this development is not matched within the Federal Republic.

There is little doubt that the German space program, which is already expanding, will continue to do so. But the expansion has a very small economic base and is proceeding at a rate which many German industrialists feel will leave German companies too far behind technologically to compete effectively for the new business of the 1970's.

Factors behind this apprehension run the gamut of economics, internal politics, external pressures, personnel complications, and the lingering public relations problem created by World War II.

The impression abroad of a rising German talent in aerospace endeavors has largely been produced by the German industrialists, who are among Europe's most enthusiastic advocates of stepped-up space activity. In recent months, for example, they have turned out in large numbers at all important conferences and trade shows, such as the Eurospace meeting in Philadelphia (M/R, May 3, p. 12) and the Paris Air Show (M/R, June 21, p. 16; June 28, p. 16), with impressive conceptual displays, reports of study efforts, and a readiness to do business.

The extent of their participation, however, belies the size of their space budget.

The government, through the Federal Ministry for Scientific Research, moved the country into several key areas of space research, beginning in 1962 with a round of study contracts. However, "the government seems shocked," as one project engineer states, "when anything reaches the hardware stage."

● **Steady but slight**—A breakdown of German expenditures for space research, both for national and international programs, since 1962, based upon figures supplied to MISSILES AND ROCKETS by officials at the Ministry's Space Research Division in nearby Bad Godesberg, follows:

	NATIONAL	INTERNATIONAL
1962	$1,425,000	$1,075,000
1963	$8,750,000	$4,375,000
1964	$12,750,000	$22,925,000
1965	$16,250,000	$27,500,000

Though these figures reflect continued growth, several things about them alarm both German industrialists and some government officials in the space sector.

For one, in 1964, the German gross national product was in excess of $100 billion, which means that the amount spent on space research was less than 0.05% of the GNP. The total spent in Germany in recent years on all forms of government-supported research and development—including defense research, nuclear, space, general science, and what is termed "assistance for studies"—was proportionally less than that spent in Great Britain, France, Sweden and Switzerland. The total ($1,975,000,000) amounted to 1.9% of the GNP in 1964.

German officials recognize that "to enable the Federal Republic to more or less keep pace with the developments in other highly developed countries, this figure must be raised to at least 3% by 1970."

An estimate of Federal funds to be requested in 1966-68 to support these various areas of research, published by the Ministry in April, indicates that requests for space research will grow to more than $290 million in new funding for the two-year period. This would raise the space portion of the total German research funds to 11%—far above the 3.6% actually received in 1963, for example, but still shy by about half of the amount requested for defense research and nuclear research. However, the figures published are only estimates and do not necessarily reflect what the government will actually appropriate.

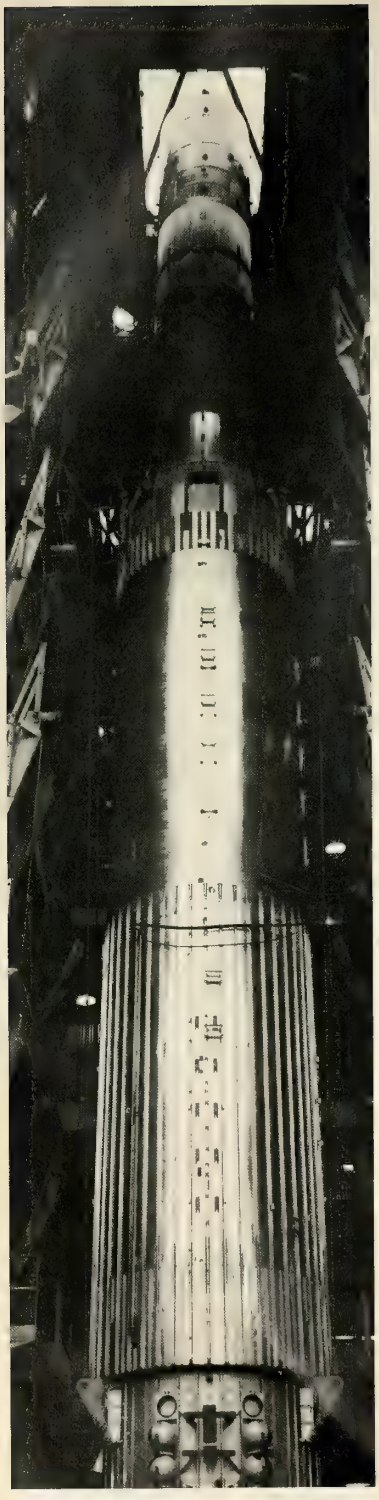
Nevertheless, the estimates provide an indication of how many persons here feel regarding the size of the space program in the immediate future. One top German industrial scientist said that $100 million, instead of the 1965 figure of $43 million, would have been more appropriate and more efficient in terms of running a national program. Others interviewed feel strongly that an annual budget of $200 million, which is indicated by the estimates for the latter half of a two-year period, is essential.

● **Roadblocks**—Despite these estimates of what should be done, officials in the Space Research Div. say the West German program, both national and international is not apt to make jumps which would double or triple expenditures annually. They report that a 30% increase in the total program for 1966, with increases at about that rate for several years, is more likely.

They note that the nation actually could not now handle much larger increases, that there are not enough administrators and space-oriented scientists available to direct the program, that teachers to train young scientists are in short supply, and that industry facilities would be taxed to handle efficiently a large and rapid increase. Furthermore, and most importantly, they feel that the West German Bundestag, or Parliament, is not now in a frame of mind to grant such large-scale increases.

● **Backing wrong horse?**—The other major flaw in the space spending figures, according to many sources here, is that the ratio of national expenses to international ones is exactly the opposite of what it should be. German experts interviewed feel that the strength of the national program is the real key to success in the international sphere.

Germany, they say, contributes roughly 20% of the funds to both the ESRO (European Space Research Organization) and ELDO (European Launcher Development Organization) projects, yet the only thing it has gotten in return is the assignment to build the third stage of *ELDO A*. Germany has been shut out of participation in any ESRO satellite project thus far.



ONLY TANGIBLE major return on West Germany's 20% support of joint European space programs is award of contract for third stage of ELDO booster, shown here. Britain is supplying the first stage of the vehicle and France the second.

The reason, say the Germans, is that not enough has been spent within Germany on the national program to build up an industry good enough to compete successfully with other nations, such as Britain and France, and return some of the invested capital to Germany.

Government sources point out, however, that while they do not favor the current balance of spending, the increase in recent years in the international expenditures has been largely due to an unexpected increase in contributions to the ELDO project, which has more than doubled the cost to the Germans.

● **Gap widens**—There are still other problems. Observers here feel that some of the aggressiveness and ambition evident in German industry must somehow permeate both the Science Ministry and the Bundestag.

Several industrialists interviewed said that what was needed in Germany was an internal development program for space similar to the one which has been successfully accomplished in the field of civilian nuclear power over the past ten years.

As matters stand, many Germans feel that the space technology gap between the Germans and the British and French is becoming wider, and not smaller as outsiders tend to see it. And they say the primary reason is the failure of the government to support the industry in developing capabilities. "Even the Italians have more space experience than we do," says one company official.

France's support of its own industry, even on occasions when it costs more than outside purchase of equipment, has wide appeal in Germany. Considerable pressure is building up here, for example, for the Ministry to reverse itself on the design of the first A-series of German satellites and use far more German components than had originally been planned. These first satellites, planned on almost a crash-program basis to gain satellite experience, were to make extensive use of U.S. off-the-shelf componentry.

Germans see a further widening of the gap between themselves and their Continental neighbors because of the peculiar arrangement of the defense budget. While French and British space technology is helped to a large degree by work carried on in the defense sector, the German defense budget, one of the largest in Europe, is not spent in areas of large missile development or military satellite design, for example, from which there is much technical fall-out.

More importantly, perhaps, a large section of the defense budget is spent outside of Germany—mostly, sources here say, because of U.S. pressure. German industry does not get the benefit of much production funding and advanced R&D.

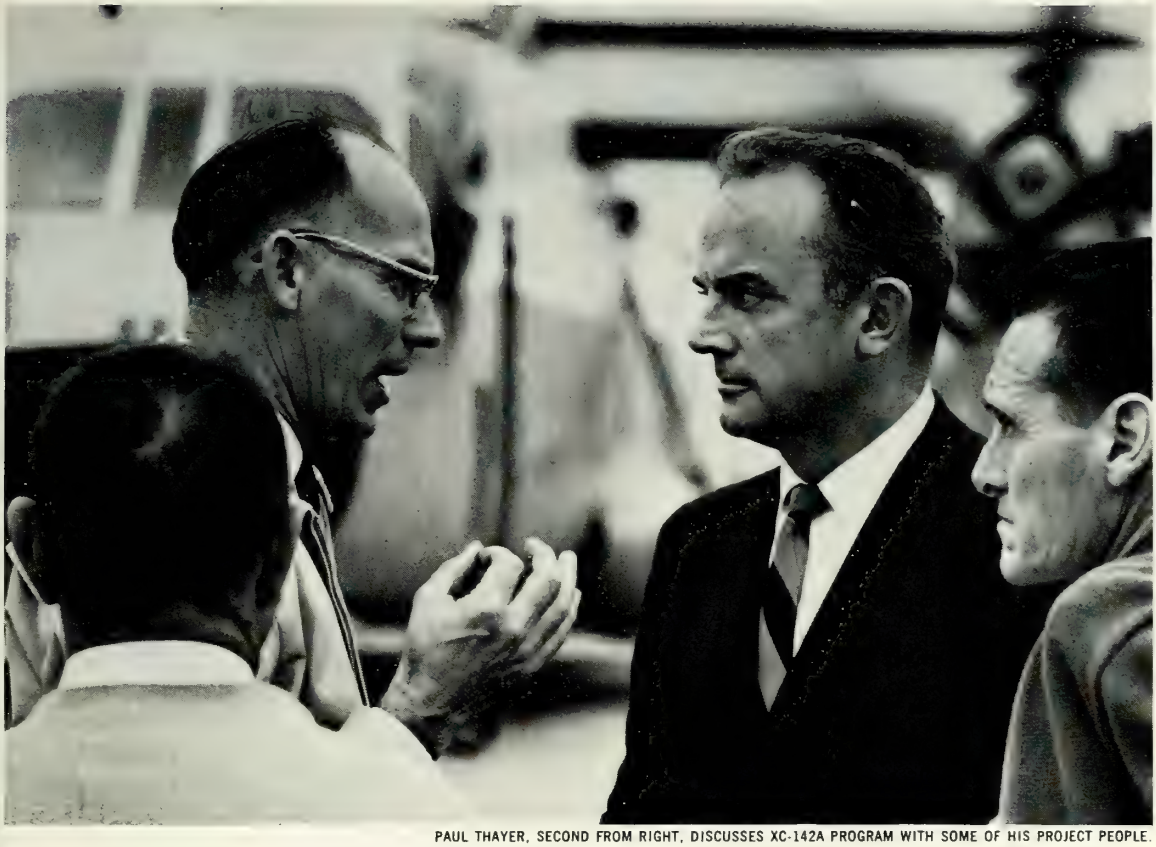
● **Political hobbles**—The Germans, with recent history in mind, still exercise restraint in terms of trying to exert pressures of their own. But there is without question a growing sense of frustration at not being able to fully use the economic resources of the country within the country.

Both government and industry officials agree that the Bundestag is still apprehensive about spending large sums of money on any items of hardware that can remotely be associated with World War II. "There is no space race here," one comments, "there is no urgency about space, and it is very difficult to convince our Parliament of the need for large-scale increases."

Despite the fact that both major political parties, through potential candidates for a September election, have stated their belief in expanding space expenditures, observers feel it is impossible to sort this out from pre-election propaganda. They add that these expressions of intent have not been made too frequently "mostly because the farmers aren't interested."

The German Commission for Space Research within the Federal Ministry recently completed a memorandum on space research, expected to be released within the next several weeks. It will propose to the Bundestag a five-year space program. The document is not expected to contain any new or startling directions, but is really aimed at helping to educate the Parliament regarding proposals which many industry and government officials have been trying for several years to promote as economically sound and technically essential. It will also recommend a speed-up in the projects already under study.

● **Existing efforts**—When the German space program began in 1962, six broad project areas were laid out and given varying degrees of support by the government. These are: Project 620—aimed at expanding existing test facilities and acquiring some new ones; Project 621—a program to develop a fully recoverable research rocket, now being worked on by Dornier and Boelkow (M/R, July 12, p. 35); Project 622—an effort to develop high-energy propulsion systems to give the Germans a specialty area where they could compete for advanced *ELDO* upper-stage contracts; Project 623—studies directed at advanced space systems, including the *Aerospace Transporter* (M/R, May 3, p. 12); Project 624—designed to study a number of areas dealing with advanced non-classical space power systems, including work on both the energy sources and conversion schemes; and Project 625—the basis for the current German satellite



PAUL THAYER, SECOND FROM RIGHT, DISCUSSES XC-142A PROGRAM WITH SOME OF HIS PROJECT PEOPLE.

"I Wouldn't Trade Jobs With Anyone in the Industry"

Paul Thayer wasn't exaggerating when he made this statement. He was simply stating a fact he firmly believes.

The question arose quite naturally — from a stockholder who wanted to know from Thayer as its president more about the current status of LTV Aerospace Corporation, its programs, its growth potential.

In the brief span of several minutes he outlined LTV Aerospace Corporation from the ground up.

He mentioned the company's divisions and the exciting projects they are engaged in, such as the *XC-142A* — the world's largest flying V/STOL, currently undergoing evaluation by the Air Force . . . the *A7A* — the Navy's new attack airplane that can go twice the distance, with twice the bomb load of any existing Navy light attack aircraft.

He talked about *Lance*, the Army's new battlefield missile that scored a bull's-eye on its first firing . . . about *M.M.U.*, the astronaut maneuvering space pack being used in Project Gemini . . . about *XM-561* — the highly versatile ground vehicle being developed for the Army . . . and about the *Scout* research rocket used by NASA . . . and about *Range* and *Launch* operations the company manages.

Finally, Thayer paused, then added, "When I think about all the projects we're involved in, the really outstanding people we have, the competitive spirit that exists, and our potential — well, I just wouldn't change jobs with anyone in the industry."

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The sphere and lens-shaped structures pictured here are test models of passive communication satellites.

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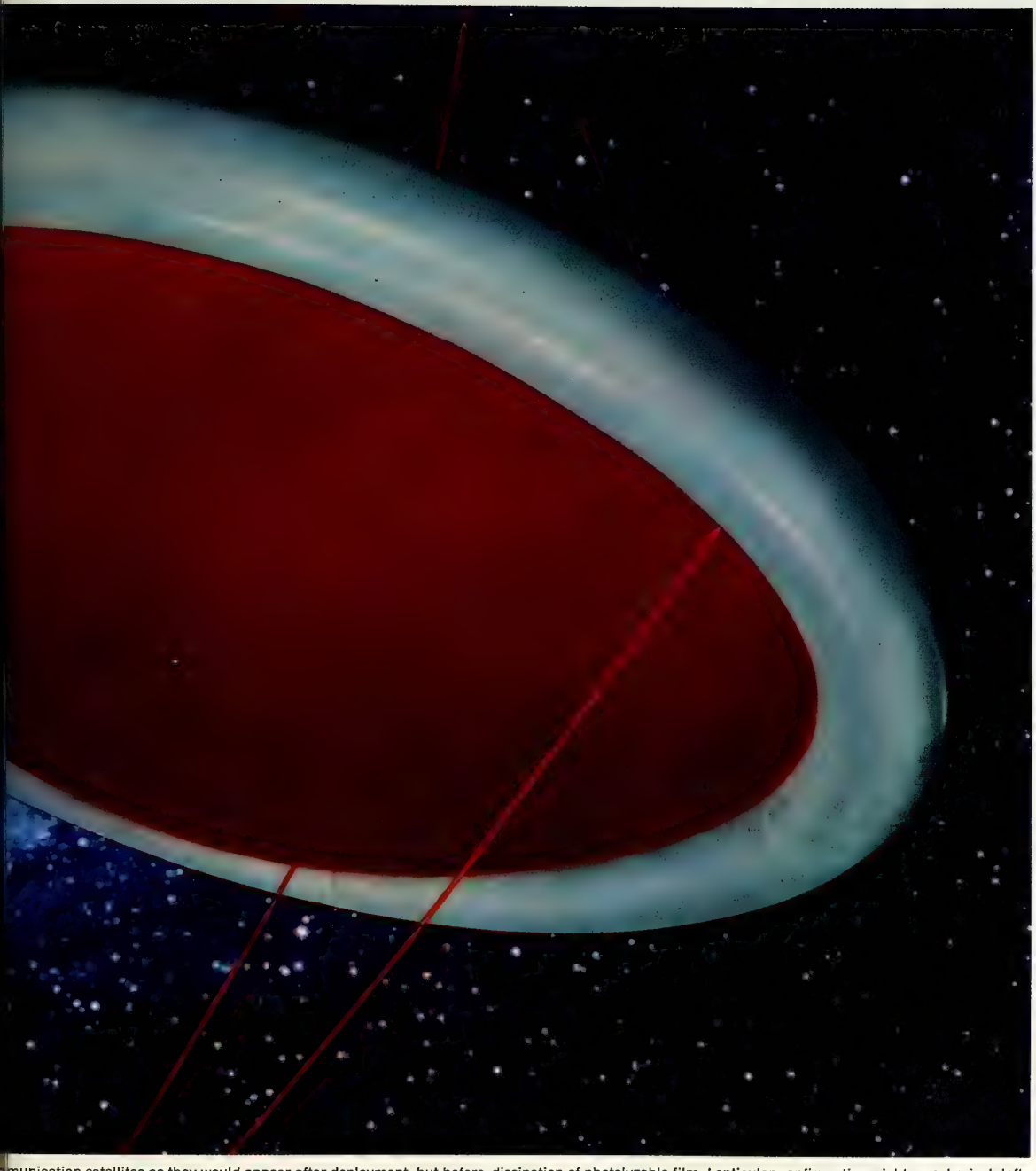

munication satellites as they would appear after deployment, but before dissipation of photolyzable film. Lenticular configuration, right . . . spherical, left.

communication satellites

avity-gradient" system to keep its "face" oriented d the earth.

e advanced concepts incorporated in these struc- exemplify the forward thinking which Goodyear pace brings to bear on problems in new areas. With sive facilities in Akron, Ohio, and Litchfield Park, na . . . and a great range of capabilities . . . GAC is am- alified for a broad spectrum of aerospace projects.

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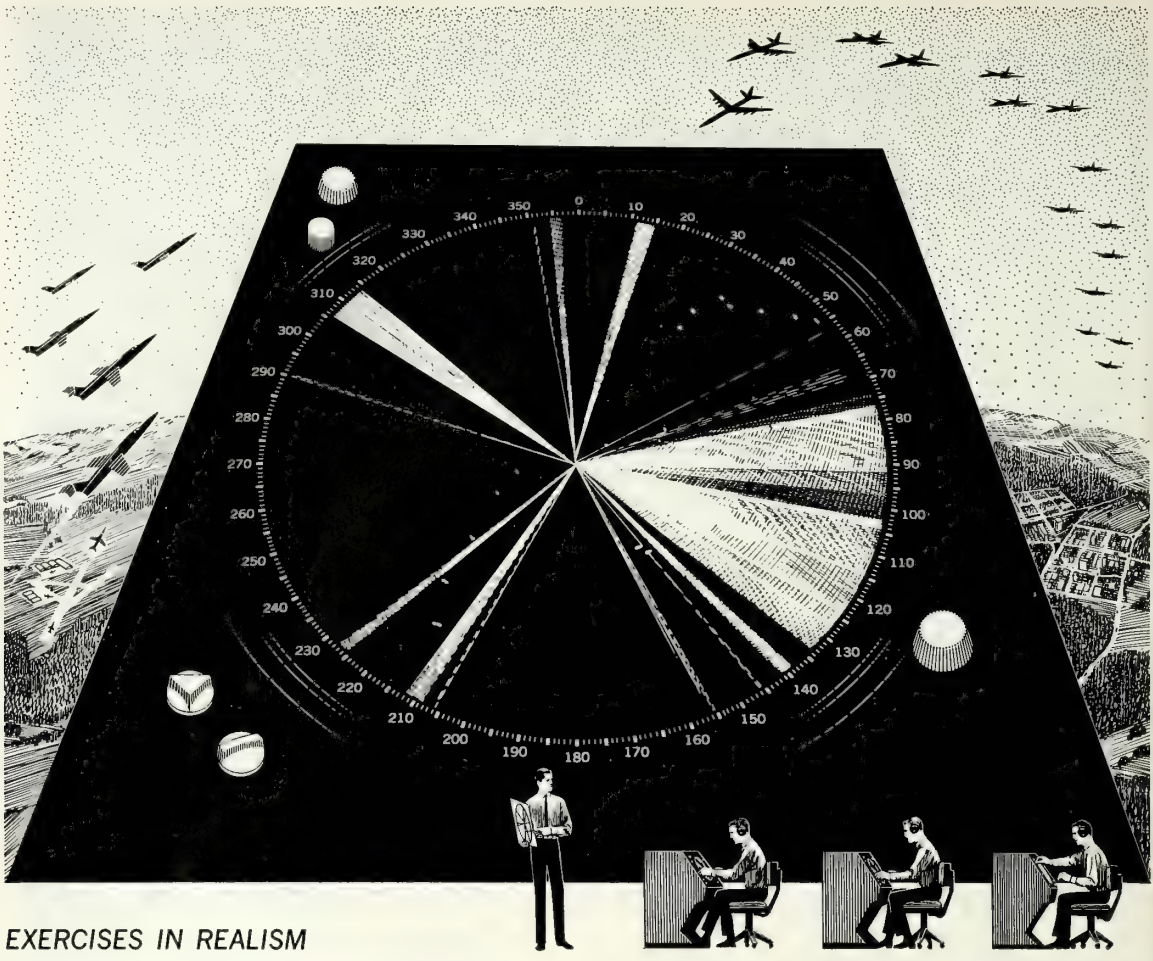

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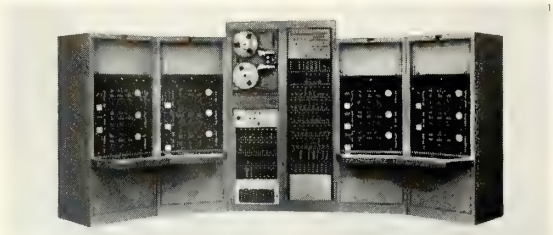

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plans, and probably the most important in terms of defining the earliest spaceflight projects.

Using these projects, most of them at present merely studies, the Germans have also set out to chart a series of practical routes to follow in terms of actually beginning a broad flight program that could be sold to the people and supported by the government. Scientists here say they are seeking to move into areas which would fill gaps in the U.S. program, both scientifically and commercially, and also offer commercial value to the Germans.

German scientists say they fully expect to duplicate some of the already developed U.S. technology, particularly in electronics, in order to develop their industry; however, they feel that there are several projects "which do not require *Saturn V* where we can specialize successfully."

● **Satellite possibilities**—For example, the Germans believe development of an inexpensive navigation satellite and ground system network would have wide acceptance for commercial aircraft and shipping. The system being studied would "not require a $100,000 installation on commercial craft to get the accuracies you might need for *Polaris* submarines."

In communication satellites, the Germans see a strong possibility of eventually competing with U.S. firms, both in satellite design and systems implementation. "It is unbelievable that there will be only American communication satellites," says one industry vice president. The Germans are particularly interested in medium-altitude systems and in new links which would provide better service to outlying countries in the British Commonwealth, for example. Studies are being funded at the three major German electronics companies in this area: Siemens & Halske, Telefunken, and Standard Elektrik Lorez.

Also, it is expected that the Germans will put in a second comsat ground station at Raistings to prepare for handover capability associated with medium-altitude satellites of the future.

Communications experts here are not very enthusiastic about use of lasers for communications, but are investing heavily in development of advanced high-traffic-capacity millimeter waveguides as a more efficient and practical replacement for traditional land lines.

The Dornier Project 621 recoverable rocket is another example of the type of gap-filler the Germans are looking for. The project is one of only a few of those originally undertaken as part of the national program which has actually reached the hardware stage. Its future, however, hangs heavily upon upcoming flights this Fall which will test the recovery and control system.

Scientifically, the German *625-A* series of satellites, while designed to get the Germans some quick experience in space, is also slated to provide a platform for what the Germans feel is a strong university specialty in solar physics.

● **625-A**—The *625-A* series actually got started in 1960, with early studies and proposals made by Boelkow in conjunction with DVL, the German Aerospace Experimental Institute. The program has been refined and the government is expected to release some $12 million budgted for the project within the next three months.

The current concept for the first satellite, *625 A-1* is based largely upon the Boelkow studies, although a prime contractor has not yet been announced. Should the government choose to use a prime, Boelkow obviously is in an excellent position. However, government sources told M/R several other contractors will be involved and that the government could decide to use several associate contractors with project management in the hands of the government-created GFW, or Company for Space Research.

A "Memorandum of Understanding" has already been submitted to NASA, which will cooperate in the project, and release of the funds is tied to the signing of the memo. NASA's Arnold W. Fruitkin, chief of the Office of the International Programs, has already visited German institutes which will take part in the project. While the *625* project is planned as a series of research satellites, the initial funds are believed to be directed primarily for the *A-1* satellite development.

The *A-1* will be launched aboard a U.S. *Scout* booster 24-30 months after contract signing. The orbit will be highly eccentric, with a 1,930-mi. apogee and 155-mi. perigee, and inclined about 102 degrees. The satellite will be 2½ ft. in dia. and 3.8 ft. long, and will weigh about 132 lbs. It will use solar cells and nickel cadmium batteries for power and will include a magnetic stabilization system and oscillation damping rods.

Five experiments expected to be aboard will measure proton and electron intensities and their energy spectra within the Van Allen belts and their fluctuations in time and distance.

If the option to extend the *625-A* series is acted upon, as is now thought likely, there probably will be two more satellites in the series, a second relatively small satellite also using the *Scout*, and a third, much heavier craft, which may require a *Thor-Delta*.

The *625-A* series is also likely to generate a requirement for satellite tracking stations within West Germany.

● **625-B**—The *625-B* series would constitute the next element in the German national program; however, this very large and advanced satellite would require an increase in space expenditures which is hard to imagine at this point, considering among other things the rising cost of supporting the *ELDO* programs.

The *625-B* satellite, based on studies carried out by Boelkow and a team of associate contractors, would involve payloads of about 530 lbs. with a total spacecraft weight of about 1,900 lbs. The satellite would be 20 ft. long and 24 ft. wide and possibly would carry advanced solar-turboelectric power systems, three-axis attitude stabilization, and PCM telemetry equipment.

The satellite, according to government officials, would not be "tied to NASA but might consider use of *ELDO* or possibly second-generation French launch vehicles."

The *B*-series was also originally intended as primarily a scientific research satellite; however, German industry officials now report the emphasis has switched to a space technology satellite similar to those being developed in the U.S. and being studied in Britain.

The Germans, along with the French and British, have also submitted design studies on the proposed *Large Astronomical Satellite* planned by ESRO for 1970-72. However, selection of the design or a contracting team is not expected to be forthcoming at any time soon.

Major problem is uncertainty regarding the launch vehicle. Choice of the vehicle will largely determine weight of the satellite. Confidence in the availability of *ELDO* boosters is not high enough to base a decision on them at this point, and there would be wide fluctuations in weights associated with different U.S. boosters such as the *Atlas* and *Thor-Delta*.

● **Transporter**—Farthest down the road for the Germans is the *Aerospace Transporter* concept. Major work on this in Germany is being done at Junkers Flugzeug und Motorenwerke AG, supported principally by Boelkow and ERNO.

Junkers engineers at the recent Paris Air Show told M/R that important advances had been made in development of lightweight structural elements and in temperature analysis which had enabled guidelines to be established for both stagnation and lower wing temperatures. Junkers also claims recent design improvements in lowering wing loadings in order to improve glide characteristics of the vehicle and lower skin temperatures.

While the *Aerospace Transporter* is in itself advancing the state of aerospace technology in Germany, mostly through studies and small test and component developments, it is not likely to play a major part in the campaign about to be launched to raise the level of national activity. ■

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Scientist Hopes for Mars Ice Layer

AF's Dr. Strughold feels Mariner photos may show evidence of subsurface ice that would simplify life support problems

HOPE THAT *MARINER IV'S* photos of the Martian surface will reveal a bonanza for space medicine are entertained by Dr. Hubertus Strughold, chief scientist of the Air Force's Aerospace Medical Division and often called "the father of space medicine."

What Dr. Strughold is looking for is the presence of white spots or a whitish color on the bottom of Martian craters or cracks, which would lend credence to his hope that a subsurface ice layer exists, covered by a layer of dust or dirt. Existence of such an ice layer would solve life-support logistics problems for a manned Mars expedition, as well as indicate the possible presence of forms of life in a water layer that might lie below.

Although he deems the theory "heretical," Strughold points out that it is not inconsistent with known facts about Mars. He says it jibes with these earlier findings and speculations:

—Localized giant clouds and white streaks of fog have been observed by astronomers P. Lowell and E. C. Slipher. These could have been produced by cracks—caused by quakes or meteoritic impacts—in the soil-covered frozen hydrosphere, allowing water to reach the surface.

Glittering white spots—like ice—have also been observed in the equatorial region. V. D. Davydov, a Soviet astronomer, revived the opinion that there might be a frozen ocean, and theorized that it would be about 500 meters thick in the equatorial regions.

—The visibility of the canal-like fissures on the Mars surface may be due to vegetation growing in these areas because of the presence of some water.

—The appearance of new areas of dark green areas on the Martian crust, like one described by Slipher, could be explained by the idea that meteoritic impacts release water, giving rise to new growth, Strughold says.

● **Strughold's experiment**—To carry the theory further, the German aviation medicine pioneer carried out a small research project simulating such a subsurface stratum and impact by meteorite.

Strughold froze alternate layers of dirt, water, and dirt in small flat pans. He then impacted them with bullets from a gun, simulating meteoritic impacts. He found that the result was craters with a whitish floor and surrounding cracks.

The cracks are important in this theory, he points out, since meteoritic hits in the homogeneous surface of the Earth do not produce such cracks. If a layer of ice existed some 100 meters below the Earth's surface, he says, it might have produced a different result.

These fissures could have been broadened, according to another theory proposed by P. A. M. Dirac of England. He says the gravitational constant has decreased during billions of years and continues to decrease. In recent years, Strughold says, this theory has been suggested to be responsible for a slight expansion of the Earth, leading to fissures and faults and split of the continents from one to another.

The lightless, hyperbaric deep-sea environment would produce a life based upon chemosynthesis in addition to that on the Martian surface which would depend upon photosynthesis. It is possible, Strughold theorizes, that remnants of an ancient life might exist in petroleum pockets.

● **Other life-support points**—Another *Mariner IV* experiment Strughold is watching closely is the radio-signal occultation experiment, which should yield important information regarding Mars' atmospheric density. If older theories that the pressure is around 85 millibars are correct, the danger of micrometeoroid penetration of spacesuit material and leakage is not as great as it would be if newer theories giving a 10-25-millibar pressure are correct. At these low pressures, Strughold points out, the astronauts would be endangered by ebullism, or boiling of body fluids, should penetration of their pressure suits occur.

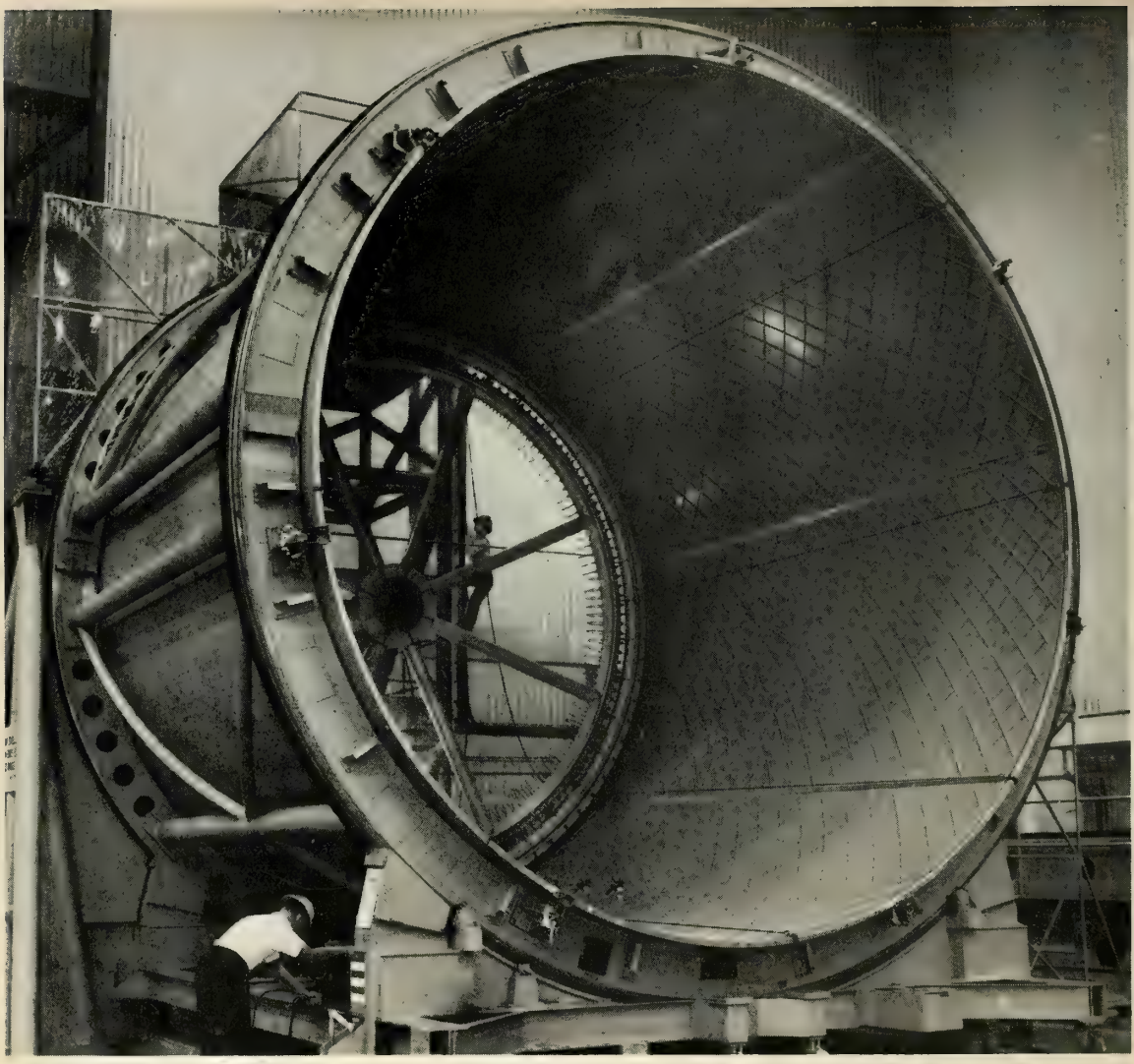
The Martian atmosphere's physical and chemical characteristics offer some advantages over those of the Moon, Strughold says. The nitrogen and argon which are supposed to exist could be utilized as resources for the pressurization of living quarters as an oxygen-diluent. Further, he suggests, carbon dioxide outside the station would be available for an oxygen-producing photosynthetic system.

Strughold stressed that the positive test for life on Mars will have to await the *Voyager* lander, in the early 1970's. Until then, all is speculation. There may well exist on Mars some state of water, an atmosphere that when simulated on Earth will not poison certain rugged forms of life, and a temperature cycle that is reasonably "friendly." For the time being, however, we have no way of knowing. ■

BIOASTRONAUTICAL DATA TABLE OF MARS *

Atmospheric pressure	65 mm Hg
Anoxia	at zero altitude
Boiling of body fluids (37°C)	at 5 km. altitude
Carbon dioxide pressure	0.16 mm Hg
Water vapor (max)	0.7 mm Hg
Mean solar constant	0.84 cal cm^{-2} min^{-1}
Albedo	0.15
Surface temperature	
Noon (max)	+25°C
Midnight (min)	−70°C
Mean solar illuminance (extra-atmospheric)	60,000 lux
Day-night cycle	24 hrs 37 min
Mars year	669 Martian days = 687 terrestrial days
Gravity	0.38 g
Gravisphere (radius)	½ million km
Circular orbital velocity	3.5 km/sec
Velocity of escape	5 km/sec

* Compiled by Dr. H. Strughold, Professor of Space Medicine and Chief Scientist, AF AMD.



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Next EVA Mission Will Test Power Tool

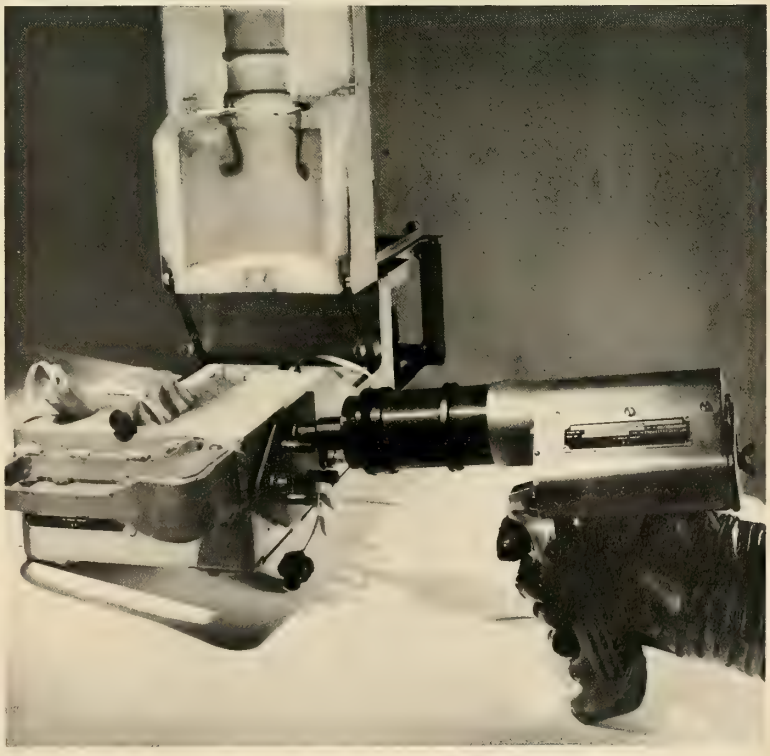
THE MARTIN CO. has delivered to the Air Force a zero-reaction power tool kit, which will be used in a DOD experiment scheduled for the next extravehicular exercise conducted by U.S. astronauts.

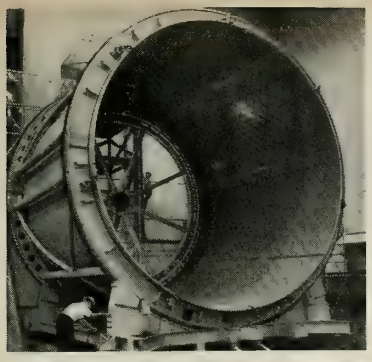
The power tool, which has a reactive torque of only 1/1,200th of the output, will be placed in the *Gemini* adapter section before the flight. During the flight, the co-pilot will move around to the adapter section, remove the tool, and test his ability to perform a maintenance task. This involves loosening nuts from bolts that hold a metal plate to the side of the vehicle, taking the plate off and turning it over, then rebolting it in place. The amount of force he is able to exert in putting the bolts back on can be measured.

The device weighs less than 8 lbs., measures 10½ in. in length, 9 in. high and 5 in. across at the widest point. It also has attachments to adapt it to a variety of purposes, including drills, thread taps, impact sockets, and general purpose chuck. Power for operating the tool is supplied by a single nickel-cadmium battery.

Nine of the devices were produced by the Martin Co., with Black and Decker Mfg. Co., as subcontractor. These include three flight-qualified tools, four working models for tests at Wright-Patterson AFB and at McDonnell Corp., and two mockups. The Air Force Research and Technology Division has conducted evaluation tests in the KC-135 zero-g flying simulator, and electronic interference testing, temperature evaluation and environmental testing were done at Martin. ■

GEMINI SPACE TOOL has a reaction torque of less than 1 in.-oz. to prevent astronaut using it from spinning while in the weightless state. As illustrated, tool is being used as an impact wrench.





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Mathematician
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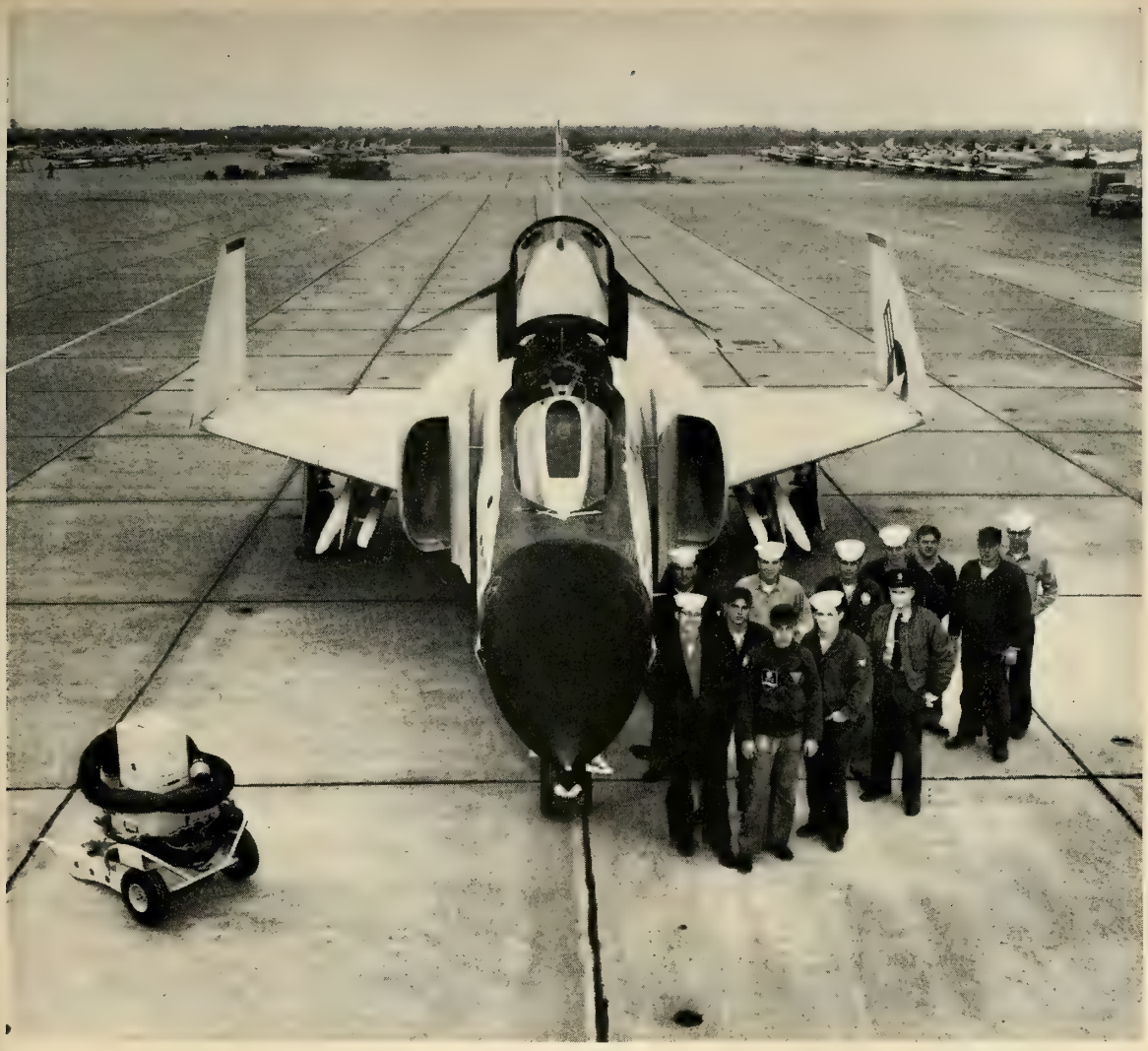
Battery Technologists
Design, fabricate, test: High energy density batteries, electrodes, separators, cases, seals, components.

Here's what it takes to service present radars in a typical fighter squadron



but the new Westinghouse AWG-10 radar cuts maintenance costs in half

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Satellite Photo Station Ready Soon

Electro-Optical Surveillance installation due to be operational at AF New Mexico station by fall; pictures expected up to 600 mi.

by Rex Pay

CLOUDCROFT, N.M.—The Air Force Electro-Optical Surveillance Station here, designed to provide pictures of satellites orbiting at altitude ranges of 100 to 600 miles, is now expected to become fully operational by fall of this year.

Main problem preventing evaluation of the imaging qualities of the 48-in. reflecting telescope and image orthicon detector is in the relay lenses used to change the focal length of the telescope. These are not as parafocal as they should be.

Also, early problems with the windscreen drive and the tracking servos prevented preliminary evaluation of the telescope during good seeing conditions, which are not expected to return until November.

The system has proved to be capable of automatically tracking satellites, chiefly at night, but has not confirmed whether it is possible to "count the rivets" on an orbiting satellite. "Now you have to have a good imagination if you are to see an image," said one engineer connected with the project.

● **Fast tracking**—The installation differs from astronomical instruments in that it is designed to follow fast-moving, low-altitude satellites. Some 2,300 lbs. of telescope and electronic equipment, above the cross-track axis, can be slewed at 1.5° per sec.

Surrounding the telescope is a 50-ft.-dia. dome that can rotate at 3 rpm. This is equipped with 180° bi-parting shutters and a wind screen to prevent dust loading on the telescope during tracking.

The main 48-in. aluminized silica mirror is mounted in what is essentially a standard astronomical tube. Newtonian and Cassegranian configurations are available with proper choice of secondary mirror. Auxiliary lenses mounted in a turret provide a means of reducing the 3,000-in. prime focal length of the mirror by successive factors of two. Quite probably this turret will soon be re-aligned at the optical facilities available at White Sands Missile Range, N.M.

A three-axis mount carries the main telescope. On its side is mounted a 15-in. secondary telescope coupled to an image orthicon to provide automatic tracking of satellites. Evaluation of this system during past months has shown it to be highly satisfactory, although a slight mechanical resonance has caused some problems at certain positions. This is currently being worked on.

● **Operator's option**—Initial acquisition of the satellite is made manually by one of two 3-in. telescopes mounted in small domes either side of the main dome. The main telescope frame is slaved to these by means of a servo system.

As the image appears in the 1° field of the 15-in. telescope, an operator viewing the tracking camera output adjusts the image to the center of the TV display. He can then either continue to track manually or switch to automatic tracking.

In automatic tracking, a narrow electronic gate is placed around the satellite's video signal and a servo system maintains the signal within this gate. Manual tracking by the 3-in. telescope continues, however, and serves as a back-up if the satellite is obscured by cloud.

Construction of the EOS station was carried out by the Research and Technology Division of the Air Force Systems Command. Nearly all the equipment has been modified since the initial installation in 1964. The equipment is likely to continue in a state of development, serving as it does as a test bed for instruments coming out of Wright-Patterson AFB. After optical image evaluation has been carried out, research will be conducted on a variety of sensors in the infrared and ultraviolet.

Most of the studies will be on U.S. satellites, as the orbits of Soviet satellites generally take them too far north of Cloudcroft for observation.

● **Tracking**—Angles of look for satellite tracking are generated from orbital elements by means of an IBM 1620 computer at the station, equipped with an IBM 1311 disc storage unit. The program generates three-axis pointing information and approximate brightness data. Tracking of satellites over the ranges of interest calls for almost single-axis motion. If lunar or planetary probes are to be tracked, the mount can be utilized in an equatorial configuration.

Prime sensor at present is an RCA commercial 3-in. image orthicon camera providing 650-700 TV lines of resolution. A similar camera is used for tracking. At the full focal length of the main telescope (field of view one minute of arc) this resolution is considered quite adequate. Use of an established commercial camera promises low maintenance costs.

Various camera tubes have been evaluated, and a GE type with an S-20 cathode has proved most useful. Image intensifiers have been investigated, but they pose problems because of their requirement for high voltages in the telescope and their susceptibility to damage by exposure to bright light.

● **No star problems**—Most tracking is carried out at night or in the early morning. So far there has been no problem with the television tracking system locking onto stars instead of the satellite being tracked. Telescope motion causes a star to pass very rapidly through the narrow video gate. A slow-moving object has been tracked during daylight to confirm that the telescope has this capability, using maximum focal length to reduce the flooding effect of skylight.

A pulse technique is used on the image orthicon to improve definition. There is no lack of light for most objects tracked. Exposure speeds well over 10,000 ASA are available with the image orthicon system.

Images produced by the telescope can be recorded on film or by means of a video recorder coupled to the image orthicon output.

Coating of the main mirror with aluminum to provide a reflectance of about 90% is carried out in a vacuum chamber located at the station. ■

breathing space

. . . Eating, living, totally preoccupied with space — that's the story of the engineers and scientists working on the LEM (Lunar Excursion Module) at Grumman, now being built for its historic journey to the lunar surface in the late sixties.

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Guidance Dynamicists — BS or MS in AE, EE, or Applied Mechanics with a minimum of 2 years' experience in the analysis of guidance systems for spacecraft, will analyze and evaluate functional configurations and dynamic characteristics of radar, IR optical and inertial guidance loops; signal processing and error analysis. Background in sampled data and nonlinear controls systems analysis techniques is desirable.

Guidance & Control Integration Engineers — BS or advanced degree with experience in design, analysis and integration of vehicle guidance & control systems. Applicants should possess a working knowledge of servo analysis techniques and subsystem and component hardware development. Position entails conceptual work in defining guidance & control systems, establishing subsystem and component requirements, system development and verification.

Control Dynamicists—BS or MS in AE, EE or ME with a minimum of 2 years experience in analysis of control systems. Will evaluate automatic flight control system requirements and performance. Familiarity with nonlinear techniques, digital control techniques and adaptive control techniques is desirable.

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Mission Control Engineers—B.S. degree with experience in flight control operations of manned spacecraft preferred. Responsibilities will include planning, preparation for, and vehicle systems monitoring in spacecraft developmental flights.

Propulsion System Field Test Engineers—For WSMR Test Operations of liquid fuel rocket engines. B.S. degree with experience in preparation, installation & test operations of full-scale hypergolic propulsion systems in atmospheric & altitude firing tests, required.

Environmental Control Field Test Engineers—B.S. degree with pertinent manned spacecraft experience preferably in Environmental Control inputs to LEM vehicle & astronauts spacesuits. Duties: Checkout planning & testing of both developmental & Flight LEM vehicles.

Propulsion System Prelaunch Checkout Engineers—B.S. degree with experience in developing & maintaining test plans & in conduct of checkout of hypergolic liquid fueled propulsion systems in field sites.

Site Activation Engineers—B.S. degree or equivalent with pertinent experience in field site installations & validations of checkout and ground support equipment. Responsibility includes planning, establishment of facility requirements, validation & activation of fluid & mechanical equipment.

(Additional opportunities in space as well as aircraft programs, on following page)

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(Continued from previous page)

Aerospace Value Engineers—B.S. in Engineering or equivalent technical ability with experience in one or more of the following: Value Engineering, aircraft design, electronics design.

Fluid Systems Test Engineers — BSME with 3 to 5 years experience in fluid systems test & checkout, & familiar with test equipment & test cell operations. Liquid rocket experience desirable.

Propulsion Test Engineers — BSME with 1 to 3 years experience in jet or rocket engine testing. Must have ability to write test plans & test procedures.

Environmental Control Test Engineers — Must be experienced in writing test plans & reports & conducting development tests on aircraft, air-conditioning, de-icing, oxygen systems &/or space vehicle life support systems. Familiarity with instrumentation requirements & lab equipment essential.

Cryogenic System Test Engineers — BSME or BS in ChE, to conduct test programs on space power generation and supercritical cryogenic H2 and O2 storage systems. Must have experience with cryogenic system operation and test, and be capable of writing test plans and reports, specifying instrumentation, and defining test set-ups, test jigs and facility requirements.

Drag & Performance Aerodynamicists—B.S. or M.S. with minimum of 3 years experience in Drag & Performance prediction applicable to conventional or VTOL aircraft.

Flight Mechanics Engineers—BS or MS in AE or Applied Mechanics with 2 or more years experience in Aircraft Dynamics. Will investigate the dynamic aspects of flying qualities including flight simulator studies, STOL, VTOL stability & control, & aircraft catapulting dynamics.

Stability & Control Engineers—BS or MS in AE, EE or ME, to perform dynamic analyses in support of vehicle aerodynamic design effort including automatic flight control systems, covering flight regimes from hovering to hypersonic. Responsibilities include: analysis of uncontrolled vehicles; establishment of stability augmentation system parameters; evaluation of vehicle flying qualities; sizing of force & motion augmenters; evaluation of transient performance and stability of flight control modes; analysis of vehicle dynamic response in disturbed flight & special flight situations. Positions available at all experienced levels.

Mission Analysis Engineers—Plan LEM missions and determine related spacecraft functional requirements. Normal and emergency operations during both development and lunar landing missions are to be considered. The work will involve contact with engineering and test sections at all levels. A minimum of 5 years experience, preferably in systems analysis, preliminary design or operation analysis is required.

Systems Engineer—Facility and Services—BS or advanced degree with a minimum of 2 years experience in establishing the requirements for facilities and the criteria for the evaluation of existing facilities. Applicants will be required to survey tests and operational sites both ashore and afloat to verify weapon system compatibility with existing facilities and support equipment. Ability to recommend and/or originate solutions to preclude potential interface difficulties is necessary. Recent military experience and/or good working knowledge of military organization desirable.

Systems Co-ordination Engineers—will coordinate a program that organizes, validates and controls the overall functional requirements of an advanced manned spacecraft project fulfilling project objective as prescribed by the procuring agency. These functional requirements are translated into over-all vehicle performance and design requirements, establishing systems parameters from which the vehicle, its major subsystems, and support equipment are designed. Task assignments include: internal and external liaison with design specialists & systems personnel & direction of the incorporation of established requirements into top systems and vehicle specifications. Applicants should possess a BS or MS in ME, EE or Physics and a minimum of 3 years of systems analysis or integration experience in a major systems effort.

Maintainability Engineers—B.S. in Physics., EE, ME, or AE with a minimum of 3 years Maintainability experience in Weapon Systems, Aero-Space Systems, or Ground Support Systems. Analytical study and proposal background as well as practical design experience is essential. Work responsibility will involve determination of maintainability requirements, performance of maintainability apportionments, feasibility studies, trade-offs, and development of maintainability programs during conceptual stages of new system developments. Background in statistics, probability, and operations research methods desirable. Airline or Military Maintenance Engineering experience in lieu of Design experience will be considered.

Air-Breathing Propulsion Engineers — BS or MS with 3 or more years applicable experience in aircraft or aircraft engines. Knowledge of compressible fluid flow, engine cycle analysis, ejector design, or induction system optimization is required. Experience with trade-off studies including cost, risk, schedule as well as weight, mission, fuel, volume & complexity is desirable. Opportunity available for growth into position of propulsion project leader on aircraft projects, & advanced development programs.

NOTE: Positions also available in the above areas to February or June '65 Engineering Graduates

Use the attached inquiry form to arrange a mutually convenient interview.

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PROFESSIONAL PLACEMENT INQUIRY

For your convenience and to facilitate your inquiry, please use this form. It will enable the professional staff at Grumman Aircraft to evaluate your background and experience and arrange for a mutually convenient personal interview. All inquiries will be held in strictest confidence. Enclose in an envelope and send to Mr. P. M. Van Putten, Manager, Engineering Employment, Dept. GR 86, Grumman Aircraft Engineering Corp., Bethpage, L.I., N.Y.

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STREET ADDRESS _____

CITY & STATE _____ TELEPHONE _____

NEAREST MAJOR CITY (IF APPLICABLE) _____

COLLEGE GRADUATE: YES___ NO___

Degree	Subject	Year

Major Specialty _____ Yrs. _____ Other Specialty _____ Yrs. _____

Applying for position(in)(of) _____

Background and experience (Brief resume of experience, recent history of employment. If available, attach prepared resume.)

Outline for Program of Main Events

MONDAY, JULY 26

9:00 a.m.

Materials for Aerospace Applications — **Room 104**
Chairman: Abraham Hurlich, General Dynamics/Convair
Coordinator: John R. Culver, Coulter Steel and Forge Co.

Plasma Propulsion I — **Room 105**
Chairman: Richard R. John, Avco Corp.
Coordinator: Charles E. Shepard, Ames Research Center

Launch Vehicle Status Reports — **Main Arena**
Chairman: R. J. Gunkel, Douglas Aircraft Co., Inc.
Coordinator: Thomas Gregory, Ames Research Center

Space Law and Arms Control I — **Room 103**
Chairman: Robert D. Crane, Georgetown University
Coordinator: C. Lowell Miller, United Technology Center

Atmospheric Flight Mechanics — **Room 316**
Chairman: Malcolm J. Abzug, Douglas Aircraft Co., Inc.
Coordinator: Walter P. Nelms Jr., Ames Research Center

Satellite Communications — **Room 106**
Chairman: W. L. Pritchard, Aerospace Corp.
Coordinator: Will Reed, Lockheed Missiles and Space Co.

12:30 p.m.

Luncheon — **TowneHouse**
Daniel J. Haughton, President, Lockheed Aircraft Corp.
"Your Role in the New Environment"

2:00 p.m.

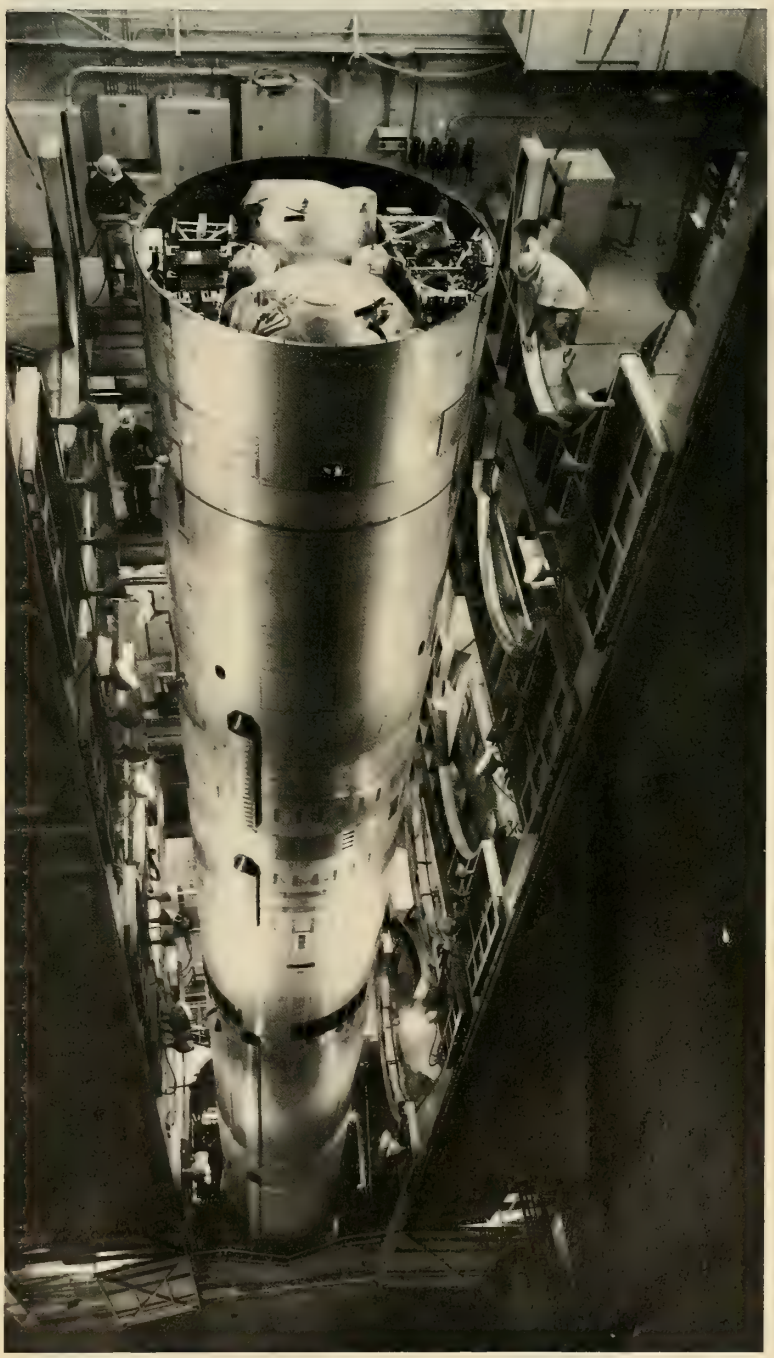
Aircraft Operations — **Room 104**
Chairman: Harold D. Hoekstra, Federal Aviation Agency
Coordinator: Walter P. Nelms, Ames Research Center

Plasma Propulsion II
Chairman: Robert G. Jahn, Princeton University
Coordinator: Gerald Street, University of California

Advanced Launch Vehicle Concepts — **Main Arena**
Chairman: Earl R. Hinz, Aerospace Corp.
Coordinator: Scott E. Gilles, Stanford University

Propellants and Combustion — **Room 316**
Chairman: William Nachbar, Stanford University
Coordinator: Gordon E. Jensen, United Technology Center

Space Law and Arms Contsol II — **Room 103**
Chairman: Robert D. Crane, Georgetown University
Coordinator: Larry J. Shannon, United Technology Center



TITAN III-A basic core vehicle at Martin-Denver. Status report on Titan III moderated by Brig. Gen. J. S. Bleymaier is slated for 9:00 a.m. Monday.

SNAP-8 REACTOR in engineering design model. Electrical power will be discussed at 9:00 a.m. Wednesday meeting chaired by E. L. Leventhal, TRW Systems Group.

Instrumentation — **Room 106**
Chairman: Bernard H. List, Texas Instruments, Inc.
Coordinator: Claude Woodard, Lockheed Missiles and Space Co.

5:30 p.m.

The Future in Aircraft Design — **Main Arena**
Moderator: David Anderton, Consultant
W. E. Gasich, Northrop Corp.
John Swihart, The Boeing Co.
Larry Mead, Grumman Aircraft Engineering Corp.
Charles W. Harper, NASA Headquarters

TUESDAY, JULY 27

9:00 a.m.

Structures — **Room 104**
Chairman: R. R. Heldenfels, Langley Research Center
Coordinator: Clayton Crow, United Technology Center

Ion Propulsion — **Room 105**
Chairman: A. Theodore Forrester, Electro-Optical Systems, Inc.
Coordinator: John P. Kesselring, Stanford University

Spacecraft — **Main Arena**
Chairman: N. J. Ryker, North American Aviation, Inc.
Coordinator: Carl A. Forbrick Jr., Stanford University

Reliability and Maintainability in Management Design and Use — **Room 103**
Chairman: F. A. Thompson, Martin Marietta Corp.
Co-chairman: C. W. Russel, Aerospace Corp.
Coordinator: Louis D. Cass, Lockheed Missiles and Space Co.

Fluid Dynamics — **Room 316**
Chairman: Jack N. Nielsen, Itek Corp.
Coordinator: Lawrence L. Lynes, Itek Corp.

Guidance and Control I — **Room 106**
Chairman: Louis K. Jensen, TRW Systems Group
Coordinator: DeLamar Watson, Ames Research Center

12:30 p.m.

Luncheon — **TowneHouse**
Bernard M. Oliver, Vice President, Hewlett-Packard Corp.
"What's Ahead in Radioastronomy"

2:00 p.m.

Structural Dynamics — **Room 103**
Chairman: Michael Dublin, General Dynamics/Convair
Coordinator: Russell E. Fahey, Ames Research Center

Electric Propulsion Applications — **Room 105**
Chairman: John Stearns, Jet Propulsion Laboratory
Coordinator: Raimund Vanderweil, Lockheed Missiles and Space Co.

Solid Rockets — **Main Arena**
Chairman: C. H. Herty III, North American Aviation, Inc.
Coordinator: Robert S. Brown, United Technology Center

The Space Radiation Environment — **Room 104**
Chairman: Alan Rosen, TRW Systems Group
Coordinator: Paul A. Forbrick Jr., Stanford University

Thermophysics — **Room 316**
Chairman: R. E. Gaumer, Lockheed Missiles and Space Co.
Coordinator: David J. Prager, Stanford University

Guidance and Control II — **Room 106**
Chairman: Louis K. Jensen, TRW Systems Group
Coordinator: DeLamar Watson, Ames Research Center

5:30 p.m.

Von Karman Lecture — **Main Arena**
Raymond Bisplinghoff, Associate Administrator for Advanced Research and Technology, NASA Headquarters

WEDNESDAY, JULY 28

9:00 a.m.

Flight Testing — **Room 104**
Chairman: A. Scott Crossfield, North American Aviation, Inc.
Co-chairman: G. A. LaRocca, North American Aviation, Inc.
Coordinator: Warren M. Zuckert, Endevco Corp.

Air-Breathing Propulsion — **Room 105**
Chairman: W. H. Bond, General Dynamics/Convair
Coordinator: John V. Rakich, Ames Research Center

Marine Systems — **Main Arena**
Chairman: Ernest G. Stout, Lockheed California Co.
Coordinator: Gilbert R. Stegan, Stanford University

History of Rocket Research Airplanes — **Room 103**
Chairman: Robert L. Perry, The RAND Corp.
Coordinator: Don Bentley, Bentley Engineers

Advanced Atmospheric Measuring Systems — **Room 316**
Chairman: Joachim P. Kuettner, Marshall Space Flight Center
Coordinator: Thomas Kruski, University of California

Electric Power Systems — **Room 106**
Chairman: E. L. Leventhal, TRW Systems Group
Coordinator: Chris W. Busch, University of California

12:30 p.m.

Luncheon — **TowneHouse**
Dr. Winston Koch, Director, NASA Electronics Research Center

2:00 p.m.

Ground Testing and Simulation — **Room 104**
Chairman: Harvey M. Cook, ARO, Inc.
Coordinator: Royce Trumbower, Lockheed Missiles and Space Co.

Underwater Propulsion — **Room 105**
Chairman: Mark I. Rudnicki, Aerojet-General Corp.
Coordinator: Munson Kwok, Stanford University

Entry Vehicle Technology and Applications — **Main Arena**
Chairman: J. F. McCarthy, Jr., North American Aviation, Inc.
Coordinator: George Kenyon, Ames Research Center

Life Sciences and Systems — **Room 103**
Chairman: Harold P. Klein, Ames Research Center
Coordinator: Richard Kurkowski, Ames Research Center

Use and Results of Advanced Atmospheric Measuring Systems — **Room 316**
Chairman: Robert D. Fletcher, Air Weather

Opportunity: accelerate the aerospace mission

The Air Force Systems Command now offers you opportunities to enhance your professional stature and knowledge at two major facilities:

The Aeronautical Systems Division. Here is the nerve center for the management of Air Force Systems Command programs, responsible for more than 50 aircraft and non-ballistic missile systems. Within ASD's authority are the F-111A and F-4C tactical fighters, the C-141 all-jet transport, the XC-142 and X-19 VTOL's and others. Located at Wright-Patterson Air Force Base, Ohio, the ASD encourages the highest standards of professional self-expression and development on the part of its multi-disciplined civilian-military team.

The Air Force Western Test Range. Operation of the Western Test Range for the National Range Division covers a vast area ranging from the Western States to the Indian Ocean. AFWTR is deeply involved in the testing of missiles and space vehicles. The complex machines of the space age raise problems of control and acquisition of data which are solved by highly sophisticated instruments. Tracking, telemetry, command, communications, computation—these are key fields of activity. A wide-ranging imagination and strong initiative are needed to advance these technologies. The following rewarding positions in the Career Civil Service are now open:

AERONAUTICAL SYSTEMS DIVISION

Aerospace Engineer (Fluid and Flight Mechanics) Project engineer specializing in thermal and mechanical loads on aircraft structures with emphasis on flight testing. Determine flight vehicle structural integrity in the environment of nuclear detonations and set systems requirements. Perform R&D tasks on criteria of structural design, aerodynamic and mechanically induced external loads, flight test load measurement, and aircraft operating limits for specific weapons systems. Thermal stress analysis with respect to thermal pulse of nuclear weapons. Vulnerability studies. Desired: Bachelor's degree in one of the basic sciences, engineering or math—plus three years of experience in Aircraft Structural Development Engineering. At least one year's experience in Structural Load Analysis.

Aerospace Engineer (Flight Systems) Responsible for flight tests of airborne systems and their components i.e. navigation, communications, radar, and automatic flight controls including approach and landing equipment. Will supervise test personnel in areas of aircraft modification, instrumentation, test system maintenance, preflight checkout, and operation of support equipment such as tracking cameras and radar. Write flight test plans and schedule flights. Typical assignment may be testing of communications utilizing the scattering effect of a resonant belt of orbiting dipoles. Desired: engineering degree in aeronautics, mathematics, electronics or equivalent plus flight test experience.

Aerospace Engineer (Propulsion & Power) For research on turbine engine components and related tasks in thermodynamics. Analyze parameters of proposed turbine engine propulsion systems. Set new technical standards based on detailed analysis of thermodynamic cycles using electronic computers. Balance turbine engine and component performance against mission requirements. Typical problems may be study of how to match turbine engine components to obtain a propulsion system giving optimum operation across a wide range of engine design points rather than the one or two points now considered. Requires engineering degree and suitable experience.

Aerospace Engineer (Materials & Structures) Project Engineer to work in the area of airframe structural fatigue life of primary aircraft components (wings, fuselage, empennage, etc.) as well as missile and missile attachment structures. Evaluate weapons system airframe service life. Establish fatigue test spectra to represent predicted service usage. Set up cyclic test programs. Determine structural modifications necessary to flight safety. Desired: Bachelor's degree in one of the basic sciences, engineering or math—plus three years experience in Aircraft Structural Development Enginering. At last one year's experience in Aircraft Structural Fatigue.

AIR FORCE WESTERN TEST RANGE

Mathematician or Electrical Engineer—Data System Analyst to assist in the preparation of computer programs. Aid in the evaluation of performance of range instrumentation and launch operations. Aid in the solution of engineering problems, processing data by means of IBM 7094 and 1460 computer equipment. Evaluate Range user requirements for studies and analyses that employ digital computers. BS in mathematics desirable plus one to three years' experience in application of advanced data processing equipment in a scientific environment.

Electronic Engineers (Instrumentation)—Aid in development, evaluation and utilization of instrumentation systems used for gathering data from space vehicles, guided missiles and aircraft. Systems will measure and analyze trajectory, velocity, position in space and other parameters. Data acquired from flight information and weapons system components are to be in such form as to permit rapid, large-volume reduction by computer and display. Instrumentation systems must approach laboratory accuracy yet work reliably with minimum maintenance under adverse field conditions. A high degree of imagination and initiative is necessary in planning and carrying out programs. Knowledge of aircraft and missile characteristics required as well as skills based on the sciences involved in systems design. BS degree desirable. 3 yrs. experience required.

Electronic Engineer (Telemetry Instrumentation)—Aid in developing ground telemetry stations. Systems are to provide up-to-date facilities for measuring, analyzing and displaying missile flight and test data and reducing this data. Measurements include altitude, acceleration, velocity, flight path characteristics and performance of components. Work is expected to result in original solutions which will set precedents for other facilities and influence new instrumentation and techniques in industry. BS degree desirable. 3 yrs. experience required.

Electronic Engineer (Pulse & Digital Instrumentation)—Aid in development, evaluation and testing of instrumentation and other electronic test-range equipment employing pulse and digital circuitry. Equipment will be used to track and maintain control of test vehicles in and outside of the atmosphere, acquire and analyze flight-test data and for range safety. Assist in developing complex electronic systems involving aerodynamic and thermodynamic variables for high-speed aircraft and missiles. Work is expected to result in significant advances in the state-of-the-art of missile and space instrumentation. A high degree of originality and judgment is required. BE degree desirable. 3 yrs. experience required.

AIAA INTERVIEWS JULY 26-29
Call Mr. Vincent Iannoli at 771-0748

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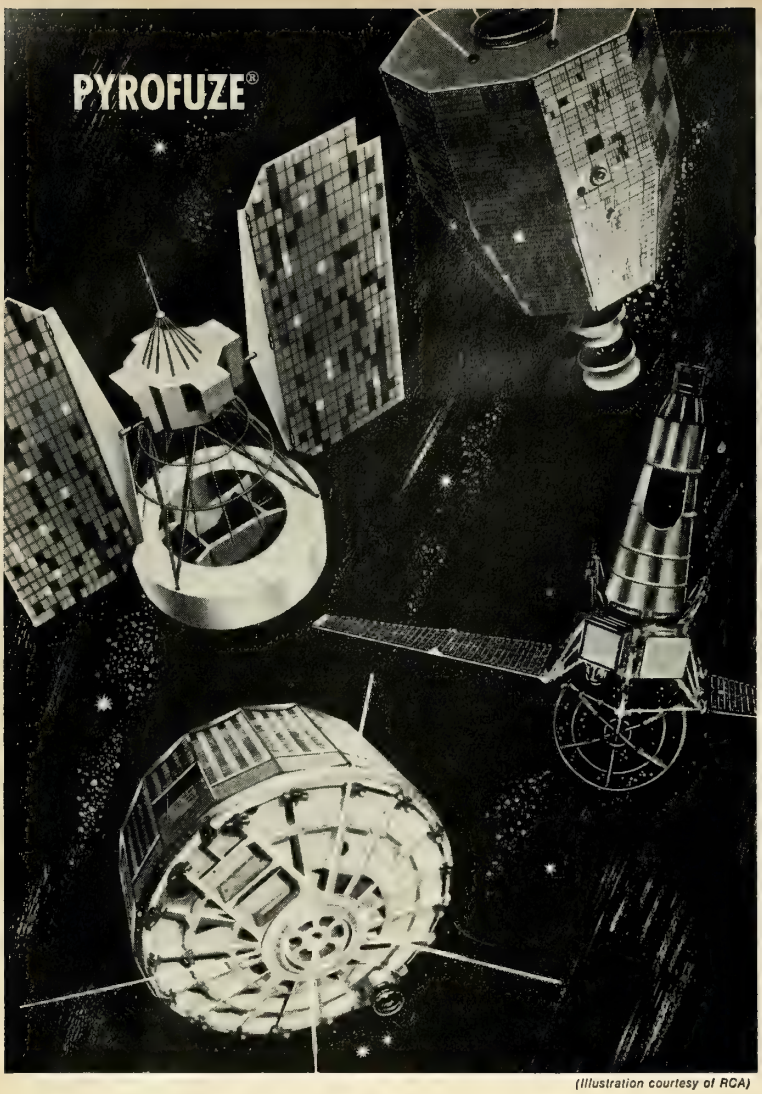

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Astrodynamics I — **Room 106**
Chairman: Robert M. L. Baker, Jr., Computer Sciences Corp.
Coordinator: John Mahoney, Lockheed Missiles and Space Co.

5:30 p.m.

Latest Events Session — **Main Arena**
Ranger Trajectory Analyses—William Kirhofer, Jet Propulsion Laboratory
Results of Mariner-Mars Fly-by Probe—William Pickering, Jet Propulsion Laboratory
Gemini Flight Results—Dr. George Mueller, NASA Headquarters

THURSDAY, JULY 29

9:00 a.m.

Ground Systems and Equipment — **Room 103**
Chairman: Kenneth Urbach, Lockheed Missiles and Space Co.
Coordinator: Norman Faber, Lockheed Missiles and Space Co.

Nuclear Propulsion — **Room 105**
Chairman: Jerry Grey, Princeton University
Coordinator: Ken Carnahan, Ames Research Center

Liquid Rockets — **Main Arena**
Chairman: Toru Iura, Aerospace Corp.
Coordinator: John D. Breazeale, United Technology Center

Management Implications of the National Space Program—Panel Discussion — **Room 104**
Chairman: R. L. Johnson, Douglas Aircraft Co., Inc.
Coordinator: Frank P. Nelson, Lockheed Missiles and Space Co.

Plasmadynamics — **Room 316**
Chairman: Daniel Bershader, Stanford University
Coordinator: Mamoru Inouye, Ames Research Center

Astrodynamics II — **Room 106**
Chairman: Robert M. L. Baker, Jr., Computer Sciences Corp.
Coordinator: Edward Tindle, University of California

12:30 p.m.

Luncheon — **TowneHouse**
Richard DeLauer, Vice President, TRW Systems Group
"Major Systems Program Management—Success or Failure?"

2:00 p.m.

Aeronautics and Astronautics in 1985 — **Main Arena**
Chairman: Abe M. Zarem, Electro-Optical Systems, Inc.
Space and the Automated Society, Simon Ramo, TRW, Inc.
Aircraft in 1985, Edward H. Heinemann, General Dynamics, Inc.
Space Science in 1985, Herbert Friedman, Naval Research Laboratory
Some Military Potentialities, Dr. Arthur Kantrowitz Avco Corp.
Interplanetary Exploration in 1985, Dr. Wernher von Braun, Marshall Space Flight Center

6:00 p.m.

Honors Convocation and Reception — **Continental Ballroom No. 2**
Richard E. Horner, President, American Institute of Aeronautics and Astronautics

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o distant planets, to land-vehicles of the 1970's, o a region far beyond the grasp of man today– he ocean bottom. Lockheed's major R & D pro- rams reach from deepest space to the ocean deep. Micro-particles, advanced concepts of re-entry, ryogenics, materials, lunar-crawling systems, utomated hospitals, data compression systems, cean mining and deep submergence–these are a ew of Lockheed's R & D interests ranging across pace, land and undersea environments. Scientists nd engineers, particularly those with an R & D nd systems bent, are invited to write Mr. K. R. Kiddoo, Professional Placement Manager, 530 ndustrial Relations Building, Post Office Box 04, Sunnyvale, California. Lockheed is an qual opportunity employer.

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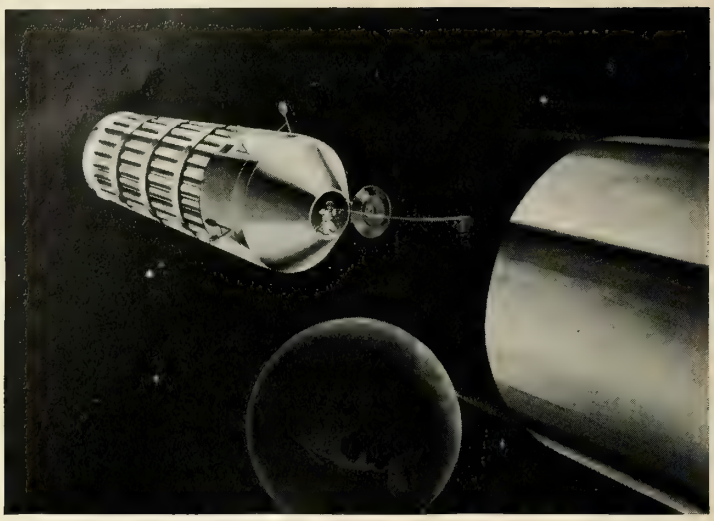

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If you're interested in learning more about openings on these many programs, write to Mr. J. S. Barson, Room 394G-3, Spacecraft Dept., Valley Forge Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia, Pa.

MISSILE & SPACE DIVISION

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(see also the other General Electric Missile & Space Division ad on page 28.)

All of these positions are in outer space

SYSTEMS ENGINEERS — ELECTRICAL

To lead and perform studies of electrical systems associated with advanced nuclear power systems for spacecraft auxiliary power and propulsion. Included here is the definition of systems requirements, determination of system characteristics, performance optimizations, and evaluation of the state-of-the-art in the areas of power conditioning equipment (static switching circuits, transformer design, etc.), alternators, E-M pump technology, control systems, electrical power transmission, and electronic payload equipment. A broad range of experience in electrical power systems and analog simulation is desired, with proven analytical ability, and skill in communicating (written and oral presentations).

LUBRICATION SPECIALIST

Chemical Engineer, Ph.D. or equivalent, with experience in lubrication, friction, and wear and an interest in solving practical lubrication problems encountered in airborne components. Understanding of spacecraft lubrication problems desirable but not mandatory.

GUIDANCE AND CONTROL SYSTEMS ENGINEERS

Conceive and conduct analytical studies resulting in the design and development of sophisticated systems for the navigation, guidance and control of Space Vehicles. Both active and passive techniques are currently under study and development for the control of Orbiting Spacecraft, rendezvous techniques, interplanetary flight and specialized military systems. Requires BSEE, ME or Physics. Intermediate and senior positions.

ENGINEERS — THERMODYNAMICS

Responsible for the design adequacy of orbital and re-entry space vehicles with respect to thermodynamics, heat transfer and aerodynamic heating factors. Will engage in synthesis and parametric studies pertaining to configuration heat protection system performances and internal cooling system performance. Requires MSME, AE or Chemical Engineering with 2 to 6 years' aerospace experience.

ENGINEERS — ORBIT DYNAMICS

Engage in earth orbit analysis, orbit determination, orbit prediction, statistical error analysis and interplanetary trajectory selection. Requires BSAE or ME with experience in celestial mechanics, orbit perturbation theory and Navigation and Guidance theory.

ENGINEERS — STRUCTURES

Perform structural loads and stress analysis on space vehicles and associated components. Support hardware design efforts, study programs and proposals. Requires minimum BS in Engineering with at least 4 years of applicable experience.

OPERATIONS ANALYSIS ENGINEERS

3 to 10 years' experience in space vehicle systems design, development, test and operations. Emphasis on hardware knowledge, systems integration and data analysis. Must be interested in responsible assignment and customer contact. Assignment is in technical support of military space programs.

PROJECT ENGINEERS

Responsible for technical direction of all work on assigned programs. This includes interpreting customer requirements, technical integration, establishing program direction and funding, and measurement of progress. Requires engineering degree, strong administrative capability and a thorough knowledge of engineering, manufacturing and quality control.

PhD — CONTINUUM MECHANICS

Theoretical studies of shock waves in solids, plastic wave propagation, and dynamic deformation and fracture of structures. Theoretical studies of the internal mechanics of composite materials including the effects of constituent geometry, inelastic and anisotropic constituents and thermal effects. Experimental and theoretical studies of constitutive relations and failure mechanisms for slow and very high strain rate effects in homogeneous, composite and layered materials and structures. Utilization of modern numerical methods for research in continuum mechanics.

ENGINEERS — COMMAND & TELEMETRY DESIGN

Responsible for the design of new spacecraft components from conceptual phase through detailed design, production, test and use. Includes airborne and ground telemetry, voice and video circuitry and sensor components. Requires comprehension of analog and digital circuitry, receiver and transmitter design experience and a knowledge of microelectronics. BS/MSEE or Physics with minimum of 4 years experience.

ENGINEERS — MILITARY SYSTEMS

Plan, direct and contribute to studies of advanced Military Space Systems by means of synthesis and design principles leading to the establishment of satellite vehicle system definition. Emphasis is placed on working systems knowledge in the field of Spacecraft Communications, Guidance and Control and Information Systems. Individuals will contribute to preproposal, proposal and contract studies. Requires MS in Systems Engineering, Physics or EE and minimum of 7 years applicable experience.

SYSTEMS ANALYSIS ENGINEERS

Interpret satellite systems design and operational mission requirements. Identify and analyze performance parameters and assess their influence on the vehicle system. Perform design trade-off analyses and prescribe acceptable systems behavior, operating domains, tolerances and performance variations. Develop the analytical facility to implement systems synthesis and optimization and evaluate development progress, malfunction, reliability, effectiveness, vulnerability and capability of the vehicle systems. Requires BS/MS EE, ME or Physics and broad understanding of missile/spacecraft subsystems.

ELECTRICAL SUBSYSTEMS ENGINEERS

Responsible for the design, development testing and qualification of the assigned Spacecraft Electrical Subsystem, including all components. Emphasis is on airborne control for the electrical distribution in a space vehicle, including electrical power and signal distribution for AGE. Requires BSEE with minimum of 4 years' applicable experience.

INFRARED AND OPTICS SPECIALIST

Responsible for originating, integrating and presenting technical studies of a systems analysis nature. Plan and direct experimental programs to validate new systems and subsystems concepts. Interpret the tactical and strategic technical requirements of the customer in the IR/Optical area and translate these into relationships that can be used for synthesis of AICBM systems. Requires MS/PhD in Physics and broad systems experience in IR and/or optics instrumentation.

RELIABILITY ENGINEERS

Individuals will be responsible for determining reliability requirements on assigned programs, to include: design, reliability; failure mode and effects; system and component analysis; test design and evaluation; failure analysis; maintainability; risk assessment; cost analysis and vendor reliability. Requires BSEE or Physics and 3 to 5 years' applicable experience.

PRODUCIBILITY ENGINEERS

Work directly with design engineering to establish manufacturing feasibility of structural, electrical, and electronic design concepts. Will act as manufacturing engineering liaison man to design engineering in the resolution of problems in the production area. Requires ME or EE with 6 to 8 years' combined engineering and manufacturing experience.

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To perform analytical studies of advanced nuclear spacecraft, with emphasis on power plant-vehicle integration problems, system "trade-off" analyses and optimization, analysis of low-thrust propulsion requirements and trajectories. An MS degree in mechanical or aero engineering is preferable. Experience need not be in nuclear area, but the incumbent should possess broad capabilities for systems analysis work and be familiar with the use of large scale computers. A recent MS graduate would be considered for this position. The incumbent will work directly with an experienced project engineer and would learn the various nuclear spacecraft technologies "on the job."

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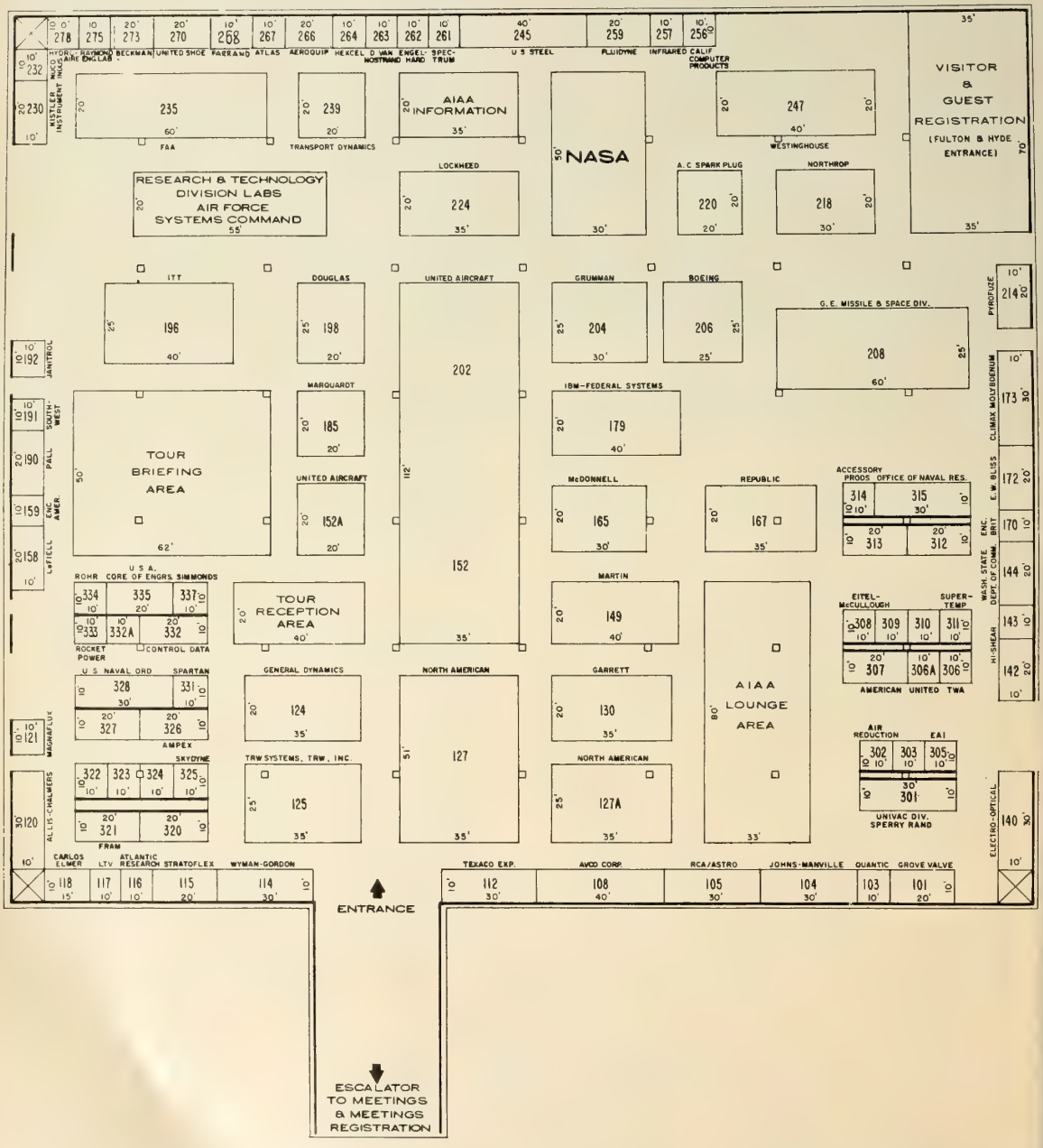
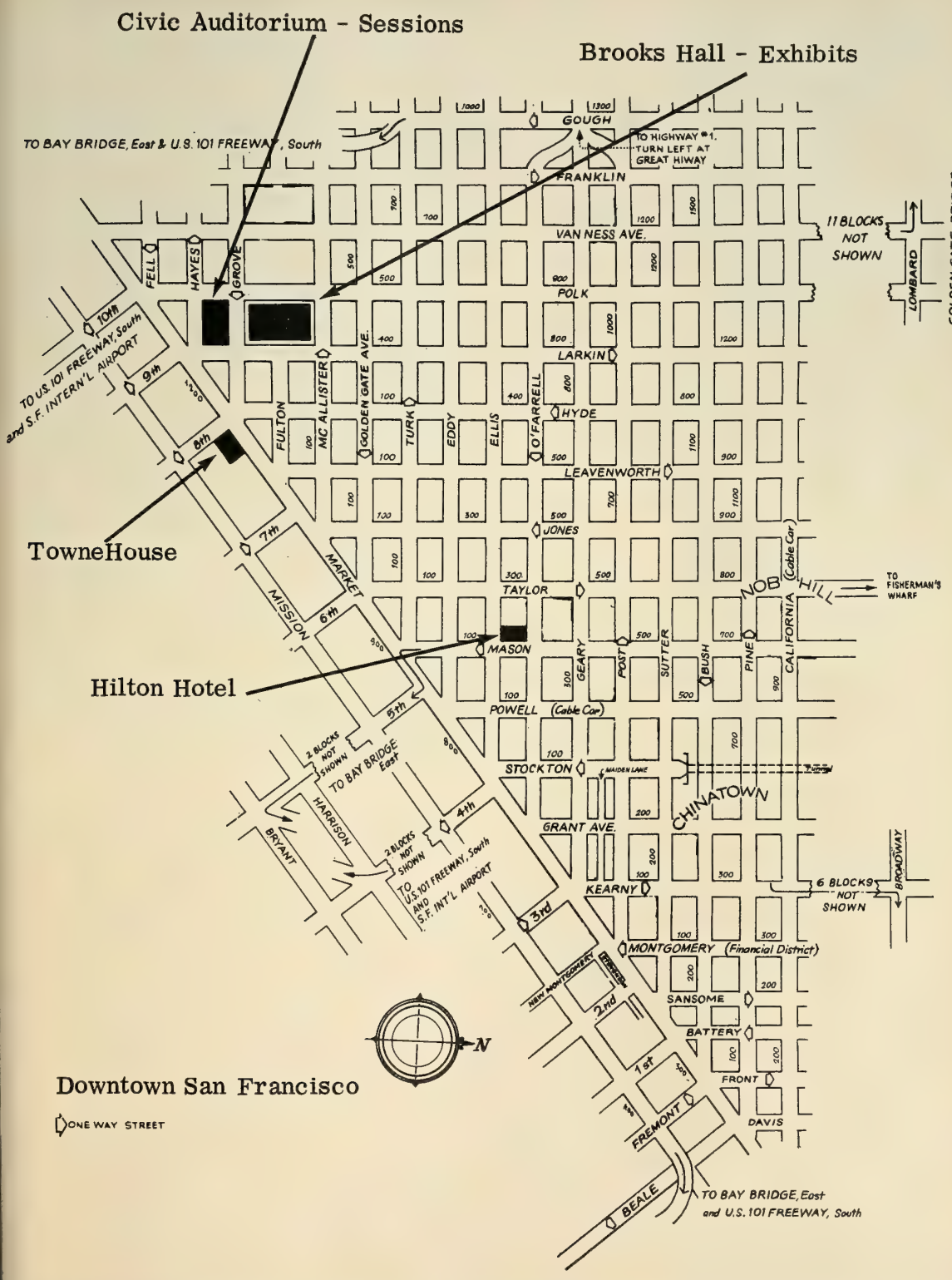
Detailed Guide to the Exhibition Area

MAP BELOW shows floor of exhibition area at the Civic Center.

Some 86 industry firms, government agencies and other organizations are participating. The map shows most of the significant exhibit locations.

Exhibits will be open to meeting participants Monday through Thursday, from noon to 9:00 p.m. The general public will be admitted only after 4:00 p.m. Thursday, when lecture demonstrations have been completed.

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Brooks Hall - Exhibits
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TO HIGHWAY #1, TURN LEFT AT GREAT HIWAY
GOUGH
FRANKLIN
VAN NESS AVE.
POLK
LARKIN
HYDE
LEAVENWORTH
JONES
TAYLOR
MASON
POWELL (Cable Car)
STOCKTON
GRANT AVE.
KEARNY
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BATTERY
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How IAS and ARS Grew And Merged into AIAA

WHEN SOME 4,000 members of the American Institute of Aeronautics and Astronautics convene next week in San Francisco for that organization's second annual meeting, the occasion will represent another step in the aerospace industry's continuing quest for cohesion.

The two mainstreams that make up the 30,000-member AIAA followed parallel paths until 2½ years ago. There were significant differences, however, and these differences still affect the merged organization. The American Rocket Society was formed as the American Interplanetary Society by a group of space enthusiasts to call attention to the great potentials of space exploration. The Institute of Aerospace Sciences, founded as the Institute of Aeronautical Sciences, was traditionally a more conservative, scholarly organization interested in the immediate problems of aviation.

At midnight, Jan. 31, 1963, the two societies became one. The common technologies of aviation and space were joined in a single, strengthened society. The first annual meeting and technical demonstration was held a year ago in Washington. Local ARS and IAS chapters have been merged and 36 technical committees cover the entire spectrum of aerospace. Headquarters have been established in the new Sperry Rand Building in New York City. The society also maintains its Technical Information Service facility on New York's Third Avenue and branch offices in Los Angeles and Brussels.

● **Way-out prophecy**—At the time of the merger, G. Edward Pendray, an ARS founding member and second president of the group, recalled that the society was born on the evening of April 4, 1930, in the top floor apartment of a small brownstone at 450 W. 22nd St. in New York. Its founders were 11 men and a woman. In announcing the organization, the society issued a prophetic statement on the reasons for its existence:

"It is our intention to build this society into a national organization with financial and other resources of such importance we can offer real inducement and stimulation to American scientists . . . in the development of rockets, rocket cars and other proposed methods of traveling in space and communicating with the planets.

"While communication with the Earth's sister bodies is not practical or possible at the present state of scientific knowledge, the solution to the chief problems is not thousands of years away but may be achievement of our own or the next generation. It is possible that many now living may see the time when a serious attempt will be made to shoot a rocket-driven car to the Moon or to a planet."

The authors of this statement were Pendray, then a reporter for the New York *Herald Tribune*, and David Lasser, a science fiction magazine editor and first president of the society. Other founders were C. P. Mason a magazine editor; C. W. Van Devander, New York newspaperman; Fletcher Prat, Science writer; Nathan Schachner, lawyer and writer; Laurence E. Manning, writer and businessman; Leatrice Gregory (Mrs. Pendray), author and syndicated newspaper columnist; William Lemkin, chemistry teacher; and three young spaceflight enthusiasts—Warren Fitzgerald, Everett Long and A. L. Fierst.

Membership grew slowly and barely topped 400 by the end of 1944. As World War II drew to a close, however, new interest in rocketry began to be felt in the United States and, in December, 1944, a private dinner in New York attracted some of the foremost men in American rocketry at that time: Dr. Theodore von Karman, Dr. Robert Goddard, Andrew G. Haley, Lovell Lawrence, John Shesta and James Wyld among them. The first national meeting was held 2 years later in New York in conjunction with the American Society of Mechanical Engineers. Three technical sessions were held. Membership rose to more than 1,000 by 1950, and during the next 10 years soared to 17,000. At the time of the merger there were more than 21,000 ARS members.

IAS was incorporated on Oct. 15,

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STORABLE LIQUID PROPELLANT ENGINEERS
Conduct storable liquid propellant rocket propulsion subsystems preliminary design and performance analysis. Knowledge of both pressure-fed and pump-fed rocket engine technology is desired, including throttling techniques, feed system dynamics, and engine heat transfer analytical techniques. Assist in proposals for major missiles and space systems programs. BS or MS with four years minimum experience including active ability to develop coded motor optimization programs.

PROPELLANT TANK HYDRODYNAMICS ENGINEERS
Conduct analytical and applied research in propulsion subsystem areas such as propellant tank hydrodynamics, fluid mechanics, boiling heat transfer in zero-g and low-g environments, and expulsion and venting. In addition, conduct applied research in cryogenic propellant behavior in long term space storage environment. MS or PhD in M.E. or Physics with five years minimum experience including active ability to develop coded analytical programs.

PROPULSION CHEMICAL KINETICIST
Conduct analytical and applied research in propulsion subsystem chemical kinetics, including non-equilibrium flow for solid, storable and cryogenic liquid propellant subsystems. MS or PhD in M.E. or Physics, plus five years experience including ability to develop coded analytical programs.

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Additional non-engineering positions are available in this scientific community for those who have an interest and experience as:

Engineering planners
Budget analysts
Rocket engine mechanics
Instrumentation technicians
Inspectors

If you are interested in exploring these or other employment opportunities at the Mississippi Test Facility, please submit your resume to:

Mr. B. G. Boyd, Professional Employment, North American Aviation, Inc., Box 1139, Slidell, Louisiana

All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

North American Aviation
Space & Information Systems Division

1932, and grew more steadily, reaching 3,000 members by the beginning of the war and continuing to grow until it had more than 15,000 at the time of the merger. Its first president, Dr. J. C. Hunsaker of MIT, recalled that the idea was born in June 1928, "when some of us met to discuss the practicability of forming an organization somewhat along the lines of the Royal Aeronautical Society." Its first annual meeting was in New York on Jan. 26, 1933, and attracted six papers. (The last IAS annual meeting in New York prior to the merger had 140.)

The list of IAS presidents reads like a Who's Who in Aviation—Donald W. Douglas, Glenn L. Martin, James H. Doolittle, Hugh L. Dryden, John K. Northrop, J. H. (Dutch) Kindelberger, J. L. Atwood, Mundy I. Peale and L. Eugene Root, to name a few. The society was also a wealthy one. It was supported by corporate members since 1936 and received major donations from Mrs. Florence Guggenheim, Sherman M. Fairchild and Glenn L. Martin. Beginning in 1962 it published International Aerospace Abstracts under contract to NASA, and this work has been continued by AIAA. ■

Von Braun Receives Hill Space Award

DR. WERNHER VON BRAUN, director of NASA's Marshall Space Flight Center, has been named to receive the 1965 AIAA Louis W. Hill Space Transportation Award on July 29 during the Institute meeting.

Von Braun, the man in charge of the *Saturn* Moon rocket program, will be cited in the presentation for "his personal contributions, and leadership in the development of space launch vehicles of unprecedented power and reliability essential for space transportation of large payloads, including man."

The Hill Award is named in memory of Louis W. Hill, transportation pioneer of St. Paul, Minn., and administered by the AIAA on behalf of the Louis W. and Maud Hill Family Foundation. It carries the second largest honorarium in the aerospace field—$5,000 to an individual or up to $10,000 for a team contribution.

Previous winners of the award are Robert H. Goddard; James Van Allen; Samuel Hoffman and Thomas Dixon; Robert Gilruth; S. Stark Draper; Robert Parks and Jack James; and Hugh L. Dryden.

Criterion for the award is "signifi-

cant contribution indicative of American enterprise and ingenuity in the art and science of space flight."

Launch of the 185-ft.-high liquid-fueled *Saturn I* booster from Cape Kennedy on May 25 of this year marked an unprecedented ninth straight success for the vehicle.

● **Wingrove also cited**—Rodney C. Wingrove, a 32-year-old engineer at NASA's Ames Research Center, has been chose outstanding young man in the aerospace field for 1965.

He will receive the AIAA Lawrence Sperry Award at the July 29 Honors

MARSHALL chief Wernher von Braun.

Convocation at the San Francisco Hilton, for first defining the guidance requirements for spacecraft Earth re-entry.

The Sperry Award is presented each year for notable contributions by a young man in the field of aeronautics or astronautics. It was endowed in 1936 by the brothers and sisters of Lawrence Sperry, pioneer aviator and inventor who died during a 1923 flight across the English Channel.

Wingrove was cited for "his continued contributions to the basic understanding and methods of furnishing guidance and control for spacecraft re-entry."

His contribution has been to pioneer research toward a firm theoretical and analytical basis for guidance and control information. He defined and analyzed the problem of guidance and the requirements for pilot information display, and from these studies formed engineering and mathematical approaches and planned and carried out a series of research investigations, first on computers and then of motion simulators. ■

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names in the news

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Andrew G. Haley: Appointed general counsel and legal adviser to the secretary-general of the International Telecommunication Union for the period of the ITU Plenipotentiary Conference to be held in Montreux, Switzerland in September.

Gordon L. Ness: Named director of marketing-instruments for the newly-created Instrument Div. of Fairchild Camera and Instrument Corp.

Thomas P. Cutler: Joined Sanders Associates, Inc., as manager of advanced systems planning. He was formerly with Management Systems Corp.

Ralph E. Moyer: Promoted to director of the missile systems division of Beech Aircraft Corp. He was formerly manager of missile engineering.

Eugene D. Richter: To be in charge of customer requirements after a recent reorganization of TRW Accessories Div.

Jack J. Marcinek: Appointed a member of the technical staff of Fairchild Space and Defense Systems, a division of Fairchild Camera and Instrument Corp.

Dr. Don R. Berlin: Appointed vice president of operations of the Curtiss-Wright Corp. He was formerly president and chief executive officer of the Vertol Aircraft Corp., later Vertol Div. of The Boeing Co.

Dr. Paul L. Howard, Sr.: Started a consulting firm, P. L. Howard Associates, Inc., in Centreville, Md. The firm will cover the fields of energy conversion, power sources, electrochemistry, oceanography and desalinization. He was vice president of Yardney Electric Corp. and remains a director.

Charles Laine: Appointed to a new post of assistant to the president of Semi-Elements, Inc.

A. S. Jerrems: Elected chairman of the 1966 Winter Convention on Aerospace & Electronic Systems, sponsored by IEEE. He is technical director of the Aerospace Group of Hughes Aircraft Co.

Alexander Sternberg: Elected vice president of the American Society for Quality Control. He is manager of projects product assurance with RCA's Astro-Electronics Div.

Oscar Bauschinger: Appointed technical director of the Gesellschaft fur Weltraumforschung mbH. From 1942 to 1956 he belonged to Wernher Von Brauns development group and was involved in the American space industry until 1964.

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JULY

European Space Symposium, sponsored by Eurospace, in conjunction with the International Exhibition of Transport, Munich, July 19-22.

Second Annual Meeting and Technical Display of the American Institute of Aeronautics and Astronautics, Civic Center, San Francisco, July 26-29.

Aerospace Reliability and Maintainability Conference, sponsored by the American Society of Mechanical Engineers, American Institute of Aeronautics and Astronautics and the Society of Automotive Engineers, Statler Hilton Hotel, Los Angeles, July 28-30.

AUGUST

Eighth Annual Space Technology Institute, sponsored by Air Force Systems Command, NASA, and University of Connecticut, University of Connecticut, Storrs, Aug. 1-13.

Tenth Technical Symposium sponsored by Society of Photo-optical Instrumentation Engineers and Air Force Systems Command, Jack Tar Hotel, San Francisco, Aug. 16-20.

1965 National Meeting of the American Astronautical Society, Sheraton Palace, Aug. 18-20.

International Lunar Geological Field Conference, sponsored by University of Oregon and New York Academy of Sciences, Bend, Ore., Aug. 22-28.

Conference on the Exploration of Mars and Venus, sponsored by Virginia Polytechnic Institute, NASA, and Air Force Cambridge Research Laboratory, Blacksburg, Va., Aug. 23-27.

1965 Western Electronics Show and Convention (WESCON), San Francisco, Aug. 24-27.

1965 International Antenna and Propagation Symposium, sponsored by Institute of Electrical and Electronics Engineers, Sheraton Park Hotel, Washington, D.C., Aug. 30-Sept. 1.

Armed Forces Management Assn. Twelfth National Conference, Washington Hilton Hotel, Washington, Aug. 31-Sept. 2.

SEPTEMBER

Second Annual Conference on the Effects of Shock and Vibration on the Human Body, sponsored by University of Denver and the Colorado Chapter of the Institute of Environmental Sciences, University of Denver, Denver, Sept. 1-3.

URSI Symposium on Electromagnetic Wave Theory, sponsored by U.S. National Committee, International Scientific Radio Union (URSI), Technological University, Delft, The Netherlands, Sept. 6.

16th International Astronautical Congress, sponsored by the International Astronautical Federation, Athens, Greece, Sept. 12-18.

Thirteenth Annual Joint Engineering Management Conference, sponsored by American Institute of Aeronautics and Astronautics, Institute of Electrical and Electronics Engineers, ASME and others, Roosevelt Hotel, New York City, Sept. 13-14.

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The Long-Delayed MOL

THE LONG-AWAITED DECISION on the *Manned Orbiting Laboratory* is one of vital importance to the nation's space effort. *MOL* marks the true point of departure for a significant military space program.

For too long, the military has been denied its proper role in space. To once again belabor the obvious, space is a place—not a program. Artificial barriers to military space development arose from a misunderstanding of this simple fact. Keeping military men out of space makes as much sense as telling the Navy that the Maritime Commission is in charge of the ocean.

The recent report by the House Committee on Government Operations makes the reason for this quite clear when it states:

"This nation is dedicated to the peaceful uses of space, but it is a matter of simple prudence and caution that the potential military uses be carefully explored and more fully known. Our military aim in space, as in other media, is always protective, not aggressive, nor directed toward destruction and world domination. Our military aim is peaceful in the sense that our Armed Forces seek to preserve peace and discourage aggression, and since space technology can contribute toward that end, it must be exploited for defense purposes."

The new Soviet leaders have in recent days spoken again of Russian anti-ballistic missile systems and orbital weapons. The Soviet record on military equipment claims is fairly straightforward. They usually have what they say they have—much to the surprise of those in this country who prefer to imagine otherwise.

The record of the Dept. of Defense in this regard also is fairly clear. We don't have an anti-ballistic missile system, we don't have a satellite inspection system and we don't have any anti-satellite system worthy of the name.

These are deficiencies which must be remedied. *MOL* has a role to play in each of these programs. It is fair to ask, then, how the record of procrastination on *MOL* developed. Two major factors are involved, and the Government Operations Committee had appropriate comment on each.

Concerning the first, the committee said this:

"The NASA Administrator, with space as his sole preoccupation, is in charge of an independent agency reporting directly to the President. The largest part of the agency's resources and energies in this decade can be devoted to a single finite goal or project—landing a man on the Moon. Its program justifications to the Congress are examined and supported by House and Senate committees especially created to oversee the agency's mission. The President and Vice President of the United States are committed by statute and personal concern, and the obvious international-prestige implications of the space effort, to close and continuing involvement.

"In the Department of Defense, on the other hand, the military space effort now is largely concentrated in the Department of the Air Force and executed by the Air Force Systems Command. The commanding officer must go through a chain of command within the Air Force to the Secretary of the Air Force, and thence to the Office of the Director of Defense Research and Engineering, and finally to the Secretary of Defense. As the Commander of the Space Systems Division proceeds up the chain, he finds that space matters are a smaller and smaller part of the responsibilities of the officials who make the key decisions upon which he waits."

The budget for military space, the committee notes, must compete with a wide range of other Defense requirements, find its way through various layers of Air Force and Defense Department supervision, and come to the Congress not as a composite space package but as various fragments in the category of research, development, test and evaluation, clothed to a large extent in unnecessary secrecy.

In the light of this awkward position for military space programs, extraordinarily competent DOD management attention is required. The committee makes clear its belief that this has been lacking:

"The military bid for substantial participation in space experimentation also has been dampened in recent years by pronouncements at the Secretary of Defense level that the military have no clearly defined mission in space, particularly in the manned space flight area . . . The negative and self-defeating attitude toward military space missions is undergoing change . . . Nevertheless, it has served to inhibit planning and development of new projects."

THIS BRINGS US to the second major inhibiting factor—and the committee does not overlook it:

"Secretary McNamara, in applying new and creative techniques of management to weed out old and prevent new projects which are technically overambitious, extremely high in cost, and uncertain in performance, also has initiated tendencies which have a retarding effect on new developments. In space particularly, there is a disposition not to authorize military programs unless there is a firm operational requirement, and absent such a requirement, the decision-makers find that the easiest decision is to hold back or to do nothing. Protracted periods of indecision, covered by repeated studies and refined analyses, cause much lost time, much wasted human effort, and less progress. Without disparaging the value of cost/effectiveness studies in given situations, we are certain that the United States cannot maintain world leadership in technology by unexceptional adherence to such concepts."

As the committee notes, it is clear that *MOL* was technologically ripe for development at least a year ago. The committee also has correctly placed the blame for the delay.

William J. Coughlin

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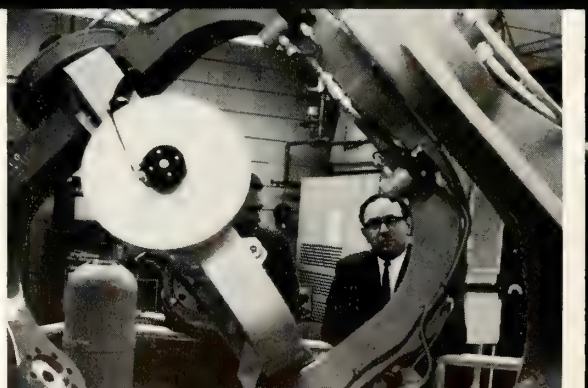

JULY 26, 1965

missiles and rockets

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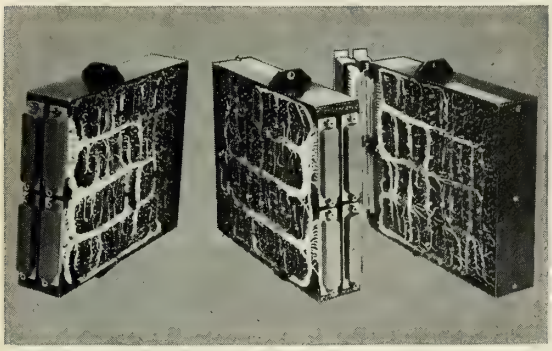
ONLY ONE major general purpose digital computer manufacturer has a data automation system on board Mariner IV[1]

MISSION — For the 228 day, 325 million mile NASA/JPL Mars flight, a 3C Space Data Automation System (SDAS) gathered scientific data and sent calibration signals to instruments which measured magnetic fields, cosmic radiation, solar plasma, and various particle intensities of outer space. As Mariner IV passed Mars in mid-July, the SDAS processed television pictures and measurements of the magnetic and related characteristics of the planet for subsequent transmission to Earth.



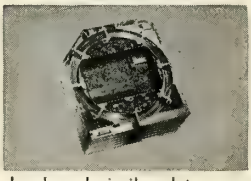
SYSTEM — The Mariner SDAS consists of three trays, each measuring 6 x 7 x 1½ inches. Two of the trays make up a non-real-time computer, while the other contains the electronics for a real-time computer. The entire system is the size of five paperback books, weighs less than 7½ pounds and occupies less than 1/10 of a cubic foot within the Mariner IV spacecraft.

MARS — BETTMANN ARCHIVE

ONLY ONE

flew a data conditioning system aboard the successful Mariner Venus fly-by in 1963.[2]

ONLY ONE

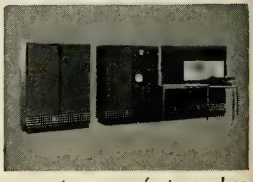


developed similar data conditioning systems for Ranger and automation systems for earlier Mariner Programs.[3]

ONLY ONE

delivered the coordinate conversion computer which positions giant antennas tracking space probes out of Goldstone.[4]

THE SAME



computer manufacturer has delivered general purpose computers to Gemini and Apollo mission simulation programs.[5]

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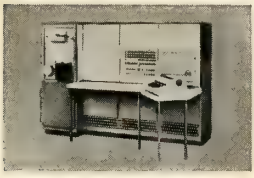

DDP-24

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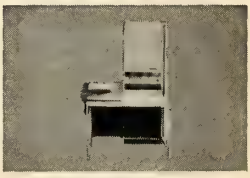

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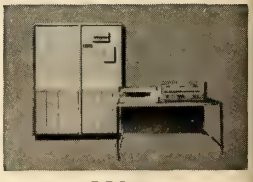

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Volume 17, Number 4 July 26, 1965

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THE COVER

Air Force Titan III-C launch vehicle roars skyward from Cape Kennedy in first launch June 18, ushering in a new military capability to orbit heavy systems. The Titan III-C is featured in MISSILES AND ROCKETS' *Ninth Annual World Missile/Space Encyclopedia, an exhaustive compilation of U.S. and foreign missiles and space systems.*

U. S. AIR FORCE PHOTO

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Compiled under direction of Associate Editor Donald Zylstra

An illustrated report on U.S. space systems, missiles and rockets—including engines, drones and sounding rockets; foreign missiles, rockets, satellites and spacecraft; and satellites presently in orbit 40

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56,500 copies this issue

Univac systems have the speed, flexibility and capacity to cope with the most complex command and tactical problems.

Military principles haven't changed much since the time of Hannibal. It's still a question of doing the right thing at the right time in the right place. It's just the astronomical complexity of the situations we have to cope with that makes the job difficult.

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The Army War Room Information System and the Air Force's Mobile Wing Recce Tech squadron have involved similar responsibilities.

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letters

Of Man Himself

To the Editor:

Adlai E. Stevenson was seldom given the occasion to comment on space exploration. When he did speak to that subject, his remarks were worth recalling.

In a Dec. 2, 1963, speech to a committee of the United Nations, he said in part:

"We often warn—and with good reason —that the pace of scientific invention may so outstrip social invention that the world's affairs will race out of control and leave us in chaos behind. But it may be worth noting that it took man tens of thousands of years to figure out how to escape his Earthly environment; and in the half-dozen years following there has been enough social invention to sustain the hope that outer space will not be chaotic.

"That hope is based on the progress that has been made so far toward freedom, peace, law and cooperation in outer space which, if pursued, could make this the first age of exploration not in the name of national glory but in the name of man himself."

Charles Corbett
Boston

Hospitality Appreciated

To the Editor:

Having just returned from an extensive tour of the American Aerospace Industry, I would like to thank all the Companies which I visited, for their universal kindness and courtesy in receiving me.

The tour included some of the steel firms in Pittsburgh and Philadelphia; Boeing, Seattle; Aerojet-General, Sacramento and Los Angeles; North American, Los Angeles; Douglas and Hughes, Los Angeles; The Martin Co., Denver; Beech Aircraft, Wichita; LTV Aeronautics, Dallas; Budd Co., Pa.; Excelco Developments Inc., Silver Creek, N.Y.; and the Naval Research Laboratory, Washington, D.C.

It is not possible to single out names in a letter of this kind, but I would like to thank everybody concerned for an instructive and enjoyable visit in which great kindness and help was shown on all occasions.

D. J. Campion
Bristol Aerojet Ltd.
Weston-Super-Mare
England

Europa in Space

To the Editor:

An audible (if unsigned) cheer for your July 12 editorial ("A European Space Proposal") as representing *the lot* of us who pretend to be civilized members of the human race. As the Book says, First, there was *the word* . . . Congratulations.

(Name Withheld on Request)
Cocoa Beach, Fla.

Mariner Accomplishment

To the Editor:

Heartiest congratulations to the *Mariner IV* team, NASA and the contractors for a truly magnificent accomplishment. *Mariner's* progress has been followed with keen interest over here.

Geoffrey Falworth
Astravista
Space Science Writers
and Consultants
Blackpool, England

To the Editor:

Praises be for *Mariner IV*, which appears to have redressed the space gap.

J. L. Morris
Houston

Reprints of Encyclopedia

Reprints of the Ninth Annual World Missile/Space Encyclopedia, appearing in this issue of MISSILES AND ROCKETS, *will be available shortly and may be obtained from:*

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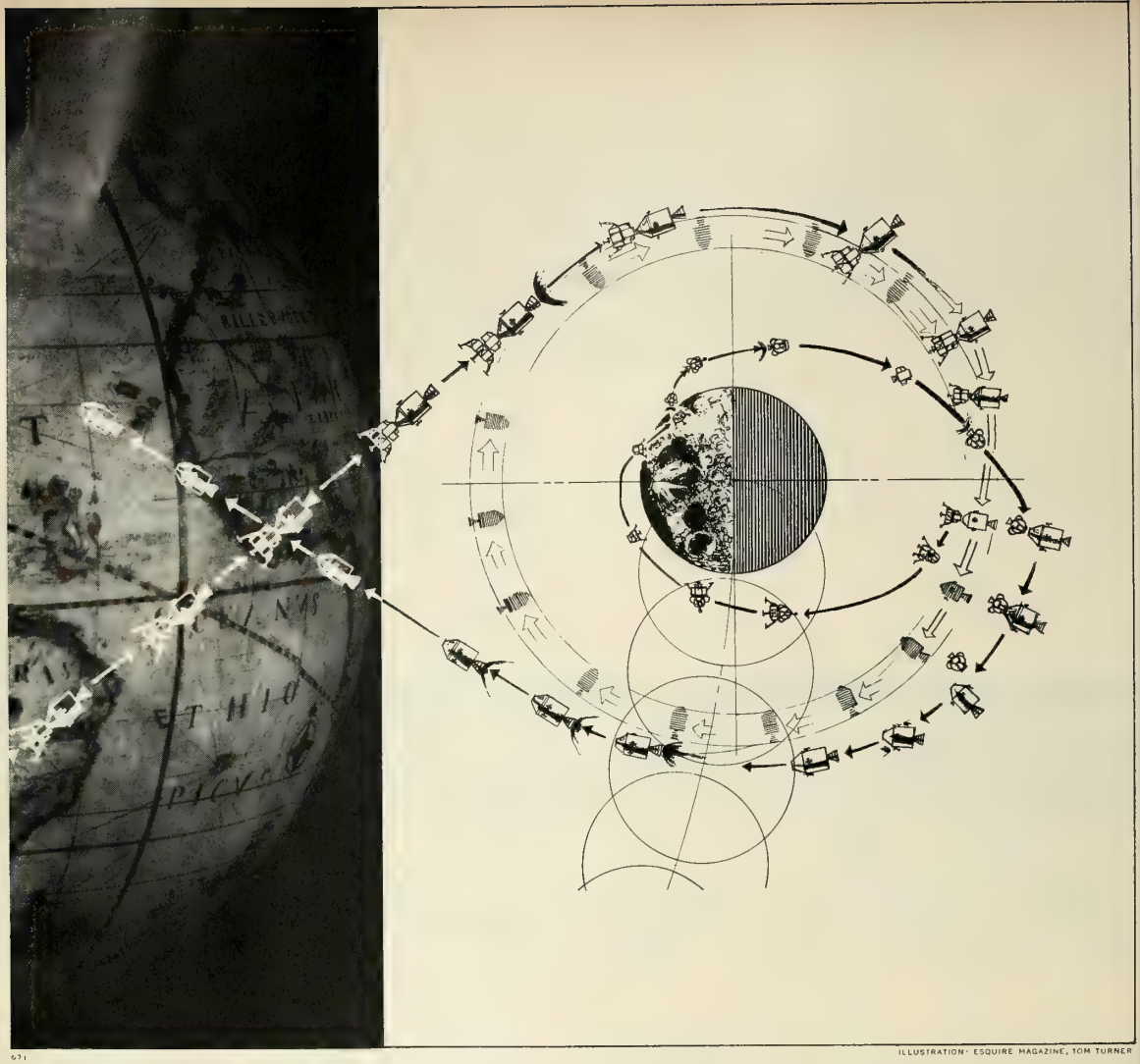

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When LEM men go down to the moon in ships...

TRW will help them get back. By 1970 two Apollonauts will descend onto the moon in their Lunar Excursion Module (LEM). A TRW propulsion system will land them feather-soft. They will explore the lunar surface, then prepare for the long journey home. After lunar blastoff they will rendezvous with their return vehicle, holding in orbit 80 miles out. During this lunar phase a TRW-built lightweight "strapdown" inertial guidance system will enhance their safety.

These major Apollo tasks have been assigned by Grumman to TRW Systems, the new name for TRW Space Technology Laboratories. TRW provides overall mission planning and analysis for NASA's Project Apollo, as it has done for the Mercury and Gemini programs.

TRW's participation in 90% of all U.S. space launches has created openings in: Inertial Guidance and Control; Mission, Trajectory and Guidance Analysis; Semiconductor Applications; Radar and Sonar; Communications and Telemetry; Experimental Mechanics; Dynamics and Structures Analysis; Aerophysics; Re-entry Systems; Spacecraft Heat Transfer; Space Propulsion; Microelectronics; Systems Research, Development and Analysis; Solid State Physics; and Applied Mathematics.

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TRW SYSTEMS

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The Countdown

WASHINGTON

SRAM Request To Be Issued Soon

Requests for proposals for the Air Force's *Short-Range Attack Missile* (*SRAM*) will go to industry by Aug. 1, the Pentagon indicates. Three major airframe firms—Boeing, Douglas and Martin—have announced plans to form teams to enter the competition to develop the system. Lockheed has announced that it does not intend to compete for the prime contract, but company officials have indicated the company intends to make a strong bid for use of its pulse motor as the *SRAM* propulsion unit. The air-to-surface defense-suppression missile would be deployed in B-52 and B-58 bombers, but designed ultimately for the Advanced Manned Strategic Aircraft (AMSA).

Russia Ready for Rendezvous?

U.S. officials believe the *Proton I* launch by a new booster on July 16 was a major step forward in the Soviet lunar landing program. One Administration expert said the vehicle has about the same payload capability as the Air Force's *Titan III-C*, and has a brand new first stage with about 2 million lbs. thrust and improved upper stages. Since the Russians have already announced they will use Earth-orbit rendezvous, the ability to orbit 25,000-30,000 lbs. in a single shot is a big advance. U.S. officials estimate that a successful lunar landing flight will require 200,000 lbs. in Earth orbit. They believe the next step in the Russian program will be an attempt at rendezvous and docking.

Surveyor Debut Likely to Slip

Launch of a *Surveyor* spacecraft this year is extremely doubtful. NASA is pushing hard to meet the last-quarter target date, but one program official admits that the schedule is awfully tight. NASA's problems with *Surveyor* were sharply illustrated last week when the agency announced it was dropping plans for a small roving vehicle to be carried to the Moon by *Surveyor*, in order to concentrate all its effort on development of the spacecraft.

Money Bills Hanging Fire

Final action on missile/space funding legislation appears to be delayed at least until the first week in August. The Senate Appropriations Committee, handling the Dept. of Defense budget, hasn't completed hearings. Conferees of the Independent Offices subcommittees of the House and Senate, working on the NASA request, are having trouble setting a date of mutual convenience, and probably will not meet this week.

Consortium Balks at New Early Bird

The Federal Communications Commission is expected to act this week on a Comsat Corp. request for permission to assemble the third *Early Bird*. It has been learned, however, that the international consortium controlling Comsat and the *Early Bird* program has already put off approval on the basis that the proposed use of the third satellite—as a backup for the second *Early Bird* or in a position over the Pacific—is not specific enough.

AES Study Bids Awaited

Manned Spacecraft Center has asked industry to submit bids by Aug. 13 for a study of the *Apollo Extension System* lunar-orbital survey mission. Objective is complete definition of the required mission, with first phase of the study to be accomplished within 45 days of contract award. Contractor will study experiment combinations, mission profiles, various configurations and integrated experiment/spacecraft design.

HHH Checks out in LEM

Vice President Hubert H. Humphrey, as part of his education as chairman of the National Space Council, recently visited the Manned Spacecraft Center in Houston and went through the tour with his customary exuberance. Among other feats, he performed a nighttime rendezvous and docking maneuver of the Lunar Excursion Module with Walter Schirra at the helm of the *Apollo* Command Module.

Sealab May Be Commanded by Carpenter

Astronaut M. Scott Carpenter, on loan from NASA, is expected to lead the first diving team on Sealab II, the undersea laboratory christened last week at Long Beach Naval Shipyard. The 57-ft. structure, accommodating a team of 10 men, will be situated on the ocean bottom a half-mile off La Jolla, Calif., at a depth of 210 ft. The 30-day experiment is being conducted by the Office of Naval Research in collaboration with the Navy's Special Projects Office as part of the Deep Submergence Systems Program. Aquanauts will practice experimental salvage techniques, perform oceanographic and marine biological research, and undergo a series of physiological and human performance tests.

INDUSTRY

Nortronic Wins Oceanographic Contract

Northrop Corp.'s Nortronics Div. has been awarded the prime management and engineering support contract for the Navy's Deep Submergence Systems Program (DSSP). It will receive $500,000 for the first year of the program, which is expected to cost $280 million during its five-year lifetime. Aims of the program include submarine rescue and extension of the "man-in-the-sea" project. Involved is a 12-14-man rescue craft capable of diving to present submarine collapse depths. Crew and craft will be flown to the site of a disaster, then operate from a modified nuclear submarine.

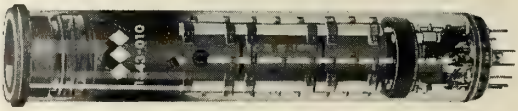
INTERNATIONAL

Eurospace Ponders Aircraft Launch Platforms

Eurospace has made public a study of the concept of airborne launchers for sounding rockets and satellite boosters, such as *Diamant*. It specifically considers a three-stage rocket launched from a Hawker Siddeley Vulcan bomber, slightly modified to carry a satellite launcher for payloads up to 750 lbs. This would bridge the gap between *Diamant* and *ELDO-A*. Other possibilities are reviewed in the paper. Among the advantages noted is a gain in performance, the aircraft acting as a reusable "half-stage."

Mariner IV looks at Mars thru a GEC vidicon . . .

The GEC 1343-010 Vidicon will be used to pick up approximately 22 pictures of the Mars surface during the 30-minute fly-by planned for mid-July, 1965. The tube will be exposed once for 200 milliseconds every 48 seconds, and the image stored on the storage surface of the tube will be read out over a period of 24 seconds without any loss of detail. The GEC 1343-010 Vidicon will operate over a temperature range from −40°C to +50°C. Developed especially for Mariner, GEC's 1343-010 is quite a vidicon!



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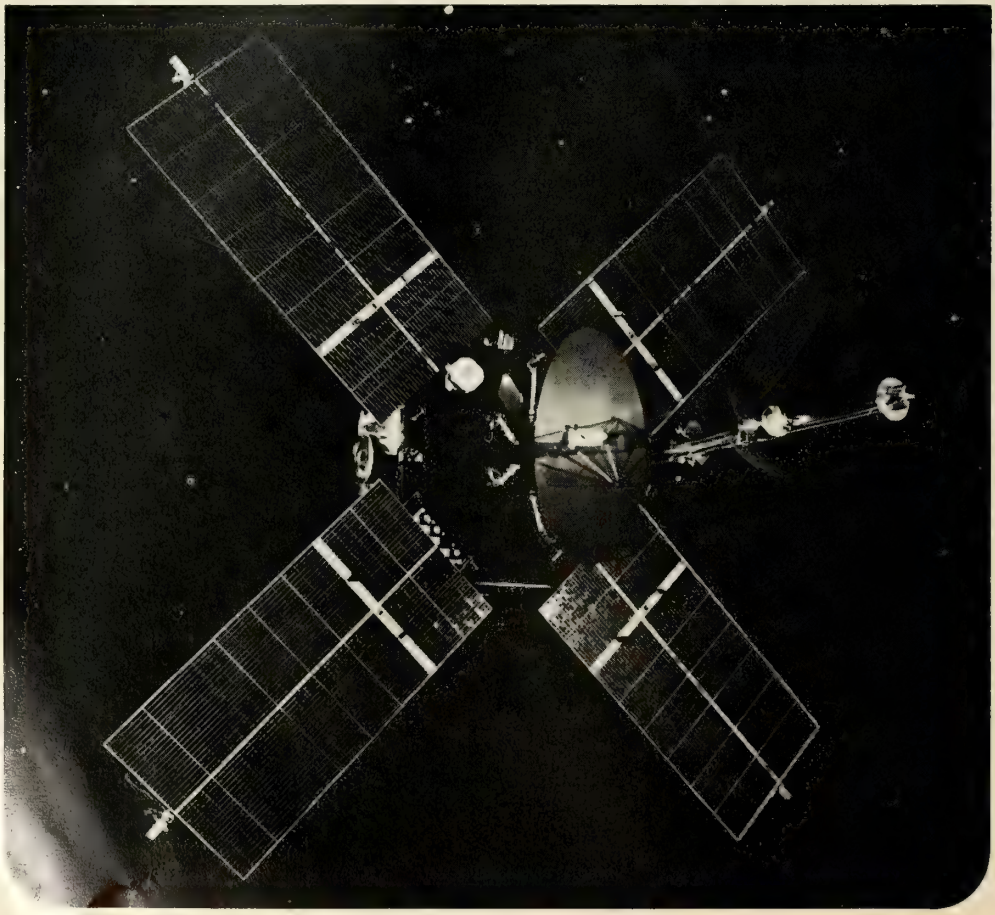

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Photos Point to Mars Landing Difficulty

by Rex Pay

PASADENA, CALIF.—*Mariner IV's* photographs and other scientific results are being refined and scrutinized on an urgent basis because of their importance to planning for the *Voyager* program.

Initial occultation data suggest that landing a capsule on Mars will be more difficult than had been expected, because of the thin atmosphere. Estimated surface pressure is only 10-20 millibars.

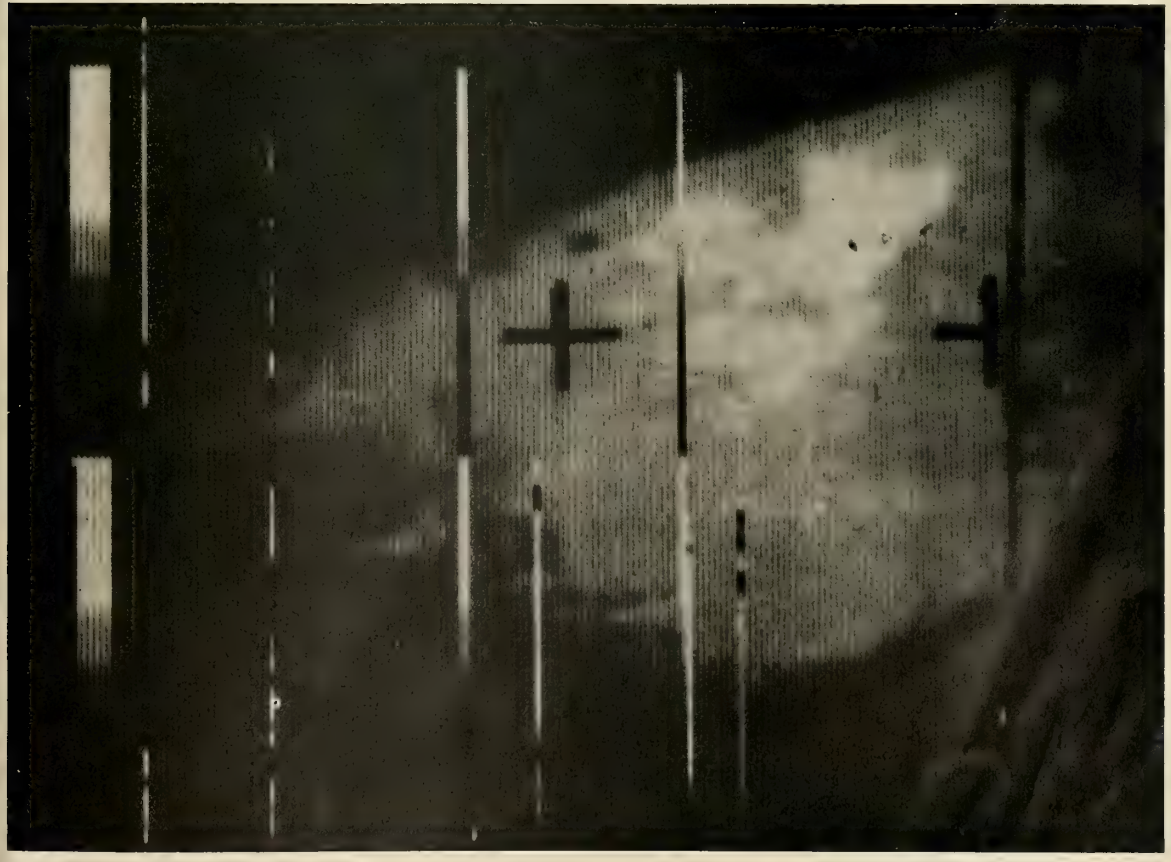
First pictures show a variety of surface features at all scales, which suggests that the location and topography of a landing site must be precisely known if scientific results from it are to be interpreted properly.

Mass estimates and the absence of trapped radiation belts or a magnetic field indicate that Mars may be structurally more like the Moon than the Earth.

These findings suggest that the *Voyager* mission will be more problematical than was anticipated, that presence of higher life forms is unlikely, and that interpretation of the Martian structure may best be carried out by first-hand examination.

● **Some life possible**—Dr. William H. Pickering, director of Jet Propulsion Laboratory, says one reason for continuing to believe that there is life on Mars is that laboratory tests show that micro-organisms can exist in an ultra-high vacuum. They could, therefore, probably survive on Mars, even though its surface atmosphere

FIRST PHOTOGRAPHIC representation of the surface of Mars radioed from Mariner IV spacecraft just before its closest approach of about 6,000 mi. View is toward the north pole, which is over the horizon. The general area in view is slightly above the planet's equator and shows the region around the bright area called Elysium. See p. 18 for further orientation of photo.



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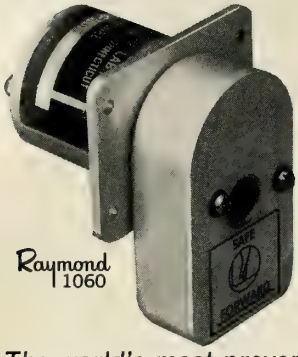

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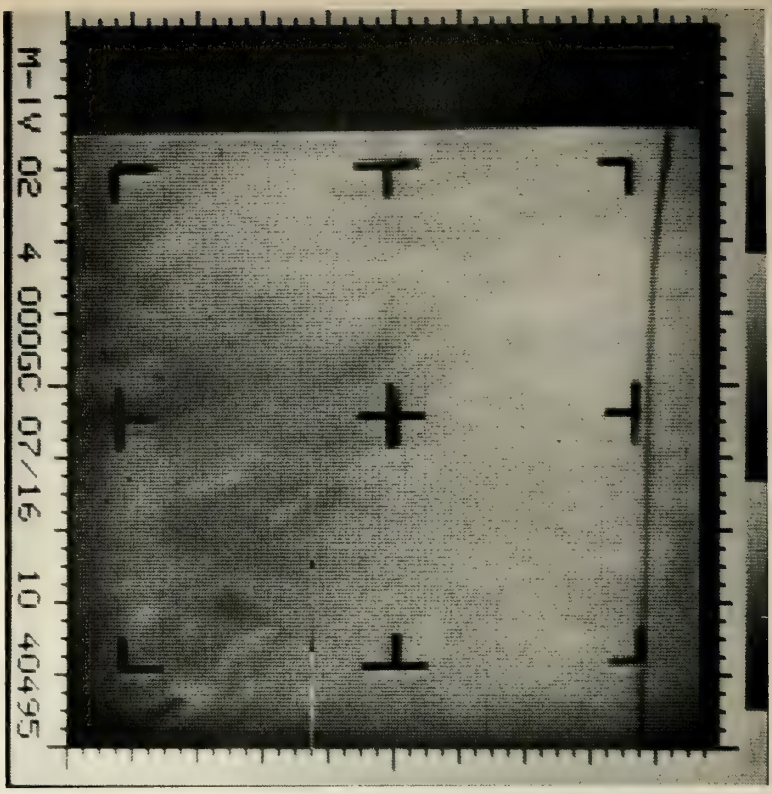

SECOND PHOTOGRAPHIC representation of digital data radioed from Mars by Mariner IV was taken from an altitude of 10,100 mi. It covers 186 mi. of the Martian surface from east to west, and 550 mi. north to south, and represents the bright areas Elysium and Amazonis, just northwest of the dark area known as Trivium Charontis. *See p. 18 for further orientation of photograph.*

is estimated to be as thin as that 100,000 ft. above Earth.

However, this also suggests the cross-contamination of the solar system by these organisms. Hence, useful deductions as to the origins of life on Mars could be made only with a very complex spacecraft, if unmanned operations are chosen.

● **Best yet to come**—The first of *Mariner IV's* pictures, seen in part and in crude form by experimenters soon after noon PDT on July 15, was released to the public some eight hours later after further processing revealed increased detail. Much more information than the picture shows remains in the television data.

In its present form, the picture led principal experimenter Dr. Robert B. Leighton to conclude that "we have seen markings on Mars that probably no one else has seen." He estimated that the picture showed 10 to 15 times more resolution than Earth-based telescopes. He was confident that later pictures taken at closer range would raise the improvement to 30 times. Details down to 5 km should be resolved, he said.

Appearance of the edge of the planet in the first picture was of outstanding importance to the *Mariner* mission. It revealed a possible fogging action in the spacecraft's camera which might have gone unnoticed if all pictures had shown only the low-contrast Martian surface. As it was, the fogging caused luminosity in the space around Mars, whereas pure black was anticipated. If it is a camera effect, the fogging can be taken out of the later pictures.

● **No sign of canals**—Martian surface features in the first three *Mariner IV* pictures show that the experimenters may be mapping a body very similar to the Moon. No canals have been identified.

Resolution improved as the camera moved closer to the surface. Slant ranges of the first three pictures were 10,500, 10,100 and 9,500 miles. Later pictures were expected to reveal more detail, as the solar lighting angle became more acute.

Confirmation that surface features in the pictures are real came with successful identification of the same features in the first two pic-

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Engineer-astronauts board a NASA Gemini Spacecraft during tests in McDonnell's new 30-foot, man-rated, high vacuum/thermal chamber. This chamber (built by Chicago Bridge & Iron Co.) permits testing of production spacecraft in simulated environments as far out as 236 nautical miles. It is the largest of 14 altitude chambers now in operation in McDonnell's Space Center.

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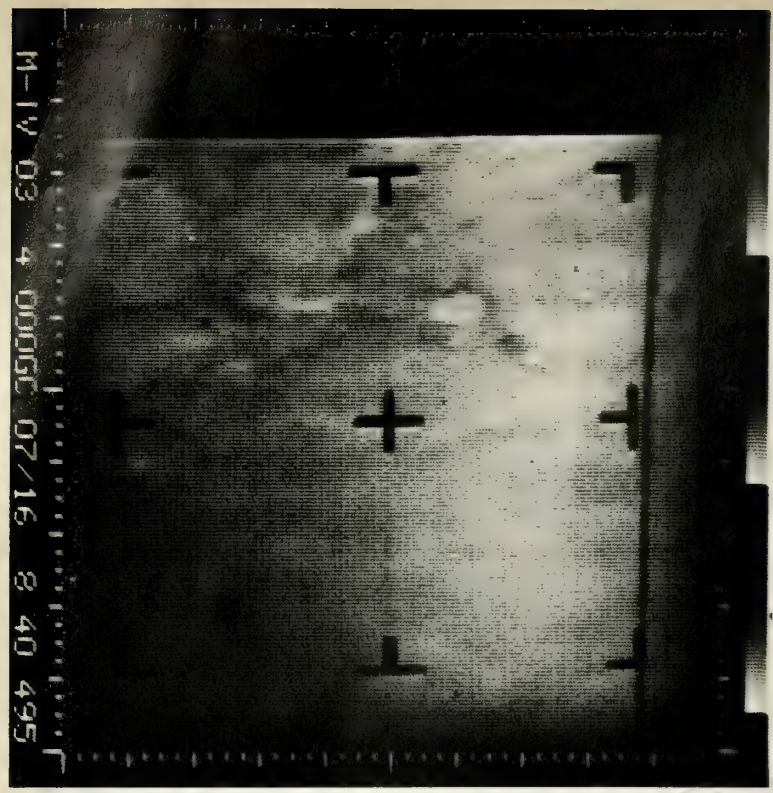

HIGH-CONTRAST photographic representation taken from an altitude of 9,500 mi. covers 175 mi. of Martian surface from east to west, and 310 mi. north to south, depicting an area southwest of Trivium Charontis on the western edge of the Amazonis Desert. Small features shown are not more than 2 mi. across, and larger feature near top center is approximately 12 mi. across.

tures. These overlap in about 25% of their area. Coverage of the second picture extends some 186 mi. east-west and 550 mi. north-south, midway between the bright areas Elysium and Amazonis.

The third picture contains some of the most interesting surface features. Covering the southwest of Trivium Charontis on the northern edge of the Amazonis desert, it appears, at first sight, to reveal dimpling and cratering similar to lunar maria. One feature looks like a crater about 12 mi. across. However, scientific investigator Prof. Bruce Murray emphasized that the angle of solar illumination meant that the feature was not to be readily interpreted as a crater.

Leighton said he was impressed by the similarity of the three pictures to photos of the Moon taken by the same camera system. They show that contrast on the surface of Mars is very low, he remarked, just as flat and featureless as parts of the lunar surface. "I will not be a bit surprised," he said, "if later missions find craters or perhaps hills under conditions of better lighting."

Leighton pointed out that maps of Mars showed "canals" in each of the areas within the first three pictures. However, he said, "I have not been able to see any evidence on any of the three frames for any narrow linear features that I would identify as a canal. . . . I have never seen a canal and that still holds true, I think."

● **Photogenic body**—Murray said he was very pleasantly surprised to find out how photogenic Mars is, since studies of photographs of the Earth taken from outside its atmosphere had led him to be very pessimistic regarding the likely content of *Mariner IV* pictures.

Murray considered that one of the most hopeful approaches to the analysis of the pictures would be to count the distributions of different sizes of craters. "This should yield some very important information on how active the surface of Mars is in terms of erosion," he explained. He cautioned, however, that it could be hard to discover even the existence of objects as large as a mountain range at the resolution being used.

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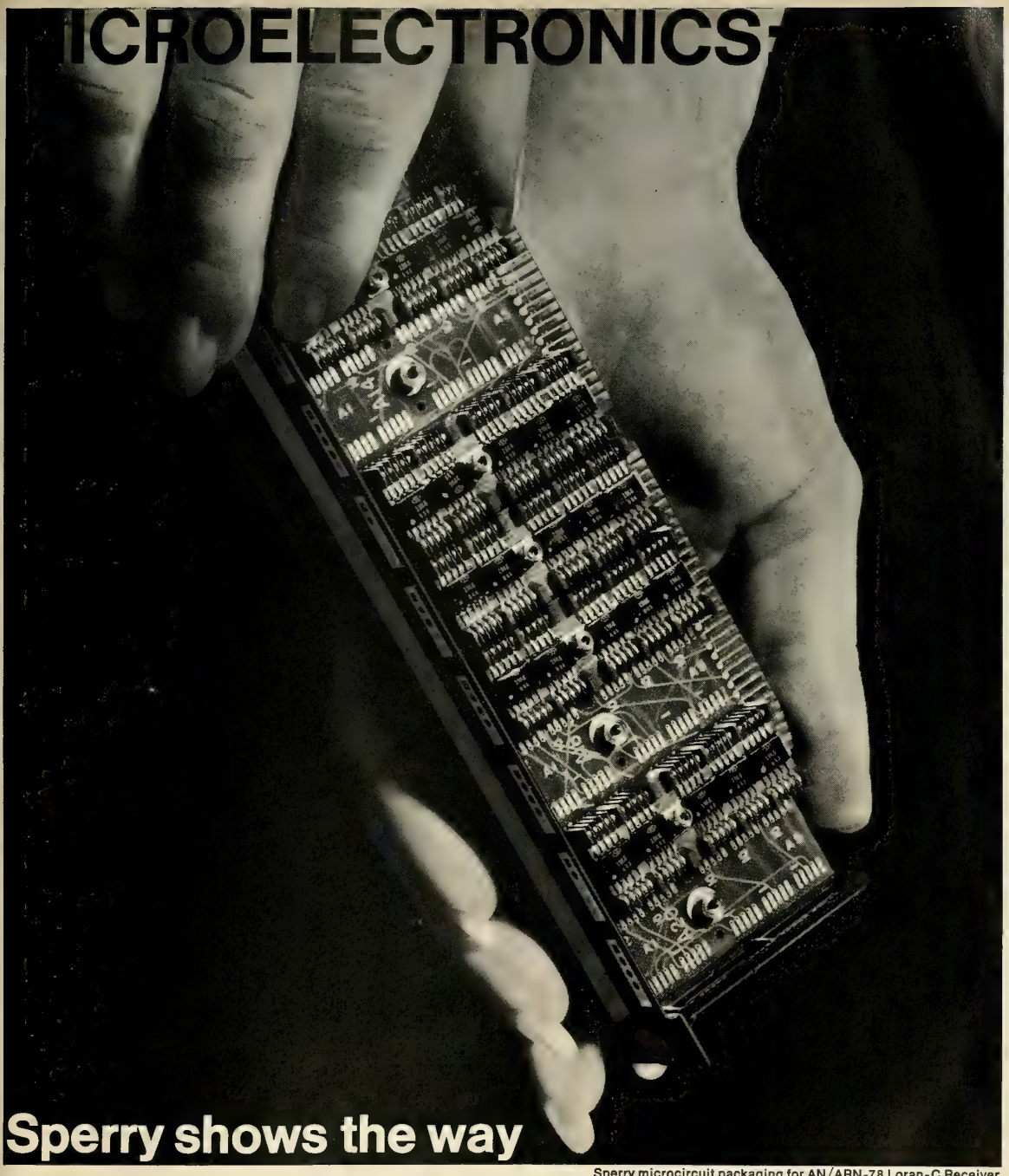

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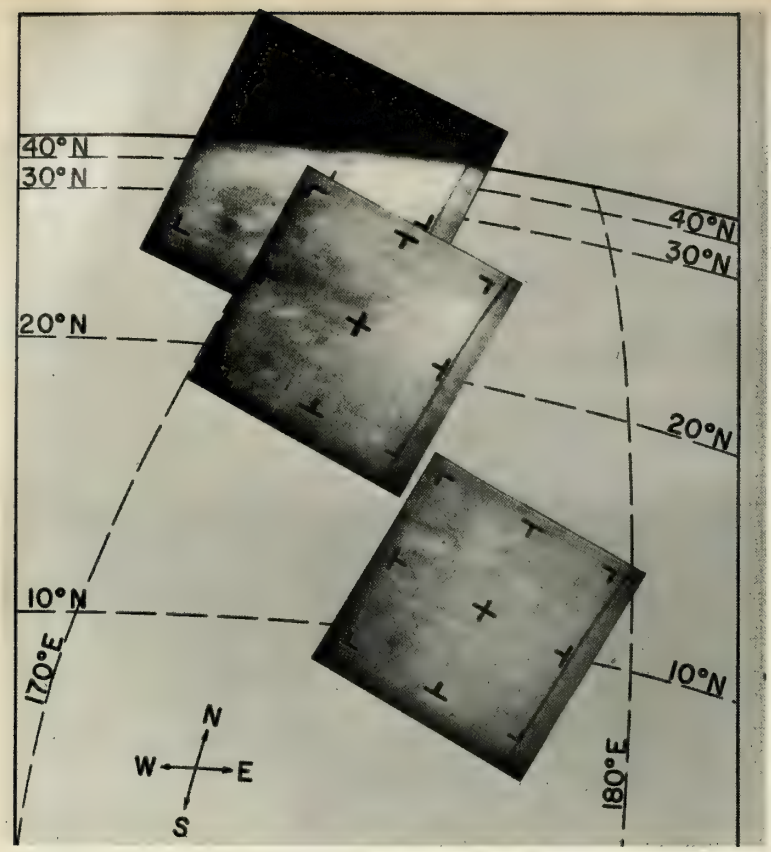

MOSAIC of the first three photographs (which appear on page 13, 14 and 16, respectively) shows overlapping of photos one and two, relative position of photo three to the first two photos, and coordinates of the Martian surface.

He said that only strong coloration would produce significant differences in overlapping picture areas viewed through the red and green filters.

All experimenters have emphasized the need to see all of the 20 or so pictures before an interpretation of the surface can be given. The last pictures, taken at the terminator, are particularly important, because they will show whether the camera is slightly fogged or there really is a picture of a cloud in the first frame.

"We have to get all of the pictures back and process them carefully," said Murray, noting that the complete set was needed before full advantage could be taken of the computer processing techniques available.

He added that it was the high accuracy of the light-measuring techniques that enabled the detailed repetitive data-processing techniques to be applied to the *Mariner* pictures. This made the television techniques much more accurate than normal photography, he said.

Mariner IV television camera engineer J. Denton Allen expressed delight with the quality of the picture data that were being received by the Deep Space Net. "We feel now that the data are very good and ought to reveal a great deal," he said.

Apparently, indeed, the data are so good that there is some question as to whether the picture sequence will be played through again. A decision will be made after all of the first set have been examined.

● **Immersion record**—Initial estimates of the Martian atmosphere came from changes in the Doppler signal from the spacecraft as its telemetry transmission passed through the ionosphere and atmosphere of Mars. These data were obtained from a closed-loop Doppler receiver at Goldstone DSIF. Amplitude information is vital to the accuracy of measurement, however, and this will be obtained from open-loop receiver records.

Immersion of the signal in the Martian atmosphere was recorded by both the closed-loop and the open-loop receivers. Immersion as the spacecraft appeared on the other side of the planet was captured only on the open-loop receivers. "But we are very confident that the open-loop receiver collected all the data," reported Dr. A. J. Kliore, principal experimenter for the Doppler measurement.

● **Lower scale height**—First estimations of the atmosphere and ionosphere were based on the Doppler shift on the immersion signal. This was compared with predicted shifts within 10-mb and 20-mb atmospheres made up of 76% nitrogen, 16% carbon dioxide and 8% argon, assuming a Mars surface temperature of −93°C. The curve of observed Doppler frequency with time fell between these two curves, suggesting an intermediate pressure. It also had a more gradual slope to start with, but had a sudden upturn. This suggests that the scale height is less than had been assumed—about 7-8 km instead of 14 km.

The point where the radio signal grazed Mars is estimated to be 55 degrees south latitude, 172 degrees longitude—south of Electris and north of Mare Chromium.

The signal-to-noise ratio for most of the occultation experiment was good—of the order of 12 db—but the critical data occurs just as the signal is being cut off. As the spacecraft dips below the planet's edge, the transmitted signal is diffracted, and a series of amplitude fluctuations is recorded on Earth. The "stretch" in the frequency of this fresnel diffraction pattern will give a measure of the near-surface conditions on Mars. The rate of change with time will give independent information about surface density and scale height (M/R, Sept. 14, 1964, p. 63).

● **Lengthy interpretation**—Extraction of these data will be a long process involving many integrations, as the signal-to-noise ratio is poor at this point. These measurements are also important in revealing the exact time at which the spacecraft's signal disappeared, thus enabling a better estimate of the final Doppler shift due to the Martian atmosphere.

It also is possible that the diffraction signal will reveal information about the scale of roughness of the planet's surface, although this information is likely to be buried in signal noise. Some corroboration of the picture information might be obtained, however.

Analysis of the amplitude variations in *Mariner's* signal is being carried out by a Stanford University team under Professor Von R. Eshleman. This team also produced a preliminary analysis of the Martian ionosphere, reporting an ionization

peak some 150 km above Mars and a density at the immersion point of 10^5 electrons per cubic centimeter. This is about one tenth of the daytime value on Earth.

Altitude of the peak is about half of that expected. In fact, the lower ionospheric peak found by one team agrees with the reduced scale height found by the other.

The *Mariner IV* pictures may give evidence of water by revealing specific types of erosion, said Murray, and the pictures might thus give an indirect indication of life. Great attention will be given to the shapes of features on the Martian surface and to contrast.

● **Processing**—The first pictures were taken with the spacecraft's camera shutter in the slow mode and minimum video gain. This exposure setting continued until picture 19, when the gain automatically increased one step, as the terminator was approached. In picture 20 the gain stepped again, and once more, to its maximum value, in picture 21. The video signal was lost in frame 20 or 21, said Allen.

First processing was in the form of a linear contrast stretch. This could have been carried out by normal photographic means with the use of high-contrast printing paper. However, the data was coming out of the JPL computer in digital forms, and it was a simple matter to use digital processing from the start. The pictures were converted into photographic form in the Link Video Film Converter, from a magnetic tape hand-carried from the computer.

The digital technique also allowed removal of noise streaks from interference and dropouts on the landlines connecting JPL with the Deep Space Instrumentation Facility (DSIF) stations around the world.

Describing the process used on the first pictures, Frederick C. Billingsley, leader of JPL's Advanced Video Development Group, said "we think we are still reasonably linear in grey scale," and pointed out that the technique was similar to bringing out mountains in a long-range picture taken through haze. "Anything you can do to bring up the contrast to show the mountains through the haze is valid, and that's what we're doing here," he said.

Billingsley said the initial contrast stretch involved a straightforward table-lookup routine in the computer. However, the digital technique will be particularly useful for more complex routines, such as pulling out detail from shadows or from bright areas. ■

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GT-5 May Track Missiles

A *Polaris* missile launched from Cape Kennedy and a *Minuteman* launched from the Pacific Missile Range may be tracked "from the pad right on up" by the *Gemini-5* crew to obtain spectral analysis of "hot" objects in space.

The plan was revealed at a press conference at NASA's Manned Spacecraft Center in Houston, by astronauts L. Gordon Cooper, Jr., and Charles Conrad, Jr., who will make more than 121 revolutions of Earth during the eight-day mission now scheduled for launch on August 19.

The radiometric measurements—one of 16 experiments on board the *Gemini-5*—are part of a broad band of readings along the electromagnetic spectrum to be made with special instrumentation carried in the spacecraft adapter. The package will be rotated outward from the adapter once the spacecraft is in orbit.

The equipment, weighing about 165 lbs., consists of three radiometers, two interferometer spectrometers, a calibration source, optics and filters.

Capt. Burden Brentnall, monitor on the DOD experiment, said the measurements will determine how spectral analyses of objects made from the ground compare to analyses made from above the Earth's atmosphere.

● **Wide-band instrumentation**—The instrumentation was designed for a general reading across a broad band of the spectrum—from 0.22 microns in the near UV region to 12 microns in the far IR region. "We are interested in objects that have a source of energy within this band," he explained.

To obtain a wide range of basic scientific readings, Brentnall said, the *Gemini-5* crew will make spectral analyses of "cold" bodies such as star fields, the Moon and major planets, of "warm" bodies such as Earth, and of "hot" bodies such as rockets emitting flame.

Rocket plumes will be observed during the spacecraft's orbital pass over the Air Force's R&D facility at Holloman AFB, N.M. A liquid rocket engine will be ignited in a horizontal static test stand to reveal its plume to the spacecraft.

The plan also calls for igniting the liquid rocket motors on the Air Force's high speed sled used in missile development and human factors research, and running it down the 35,000 ft. test track.

IR signatures of rocket plumes outside the Earth's atmosphere may be made from actual missile launchings, depending on weather.

Cooper said the missiles will go to a higher altitude than that of the *Gemini-5* which will vary from 95 mi. at perigee to 190 mi. at apogee. He will use an optical sighting device in his window during the tracking task to keep the instrument aimed at the missile.

● **OAMS fuel allotment**—Conrad said that the expenditure of orbital attitude and maneuvering (OAMS) fuel has not been determined yet, but that the greatest expenditure will be allotted to the rendezvous exercise with the REP, and the in-plane maneuvers afterward around the pod.

"This is an expensive maneuver around the pod," Conrad said, adding that it will involve station-keeping with the object for about 25 min. "The maneuver is within the budgeted fuel for rendezvous," he said, even though it is a separate experiment.

"We want to get pictures of the pod from different light angles," Cooper explained. The photos will determine how well *Gemini-6* pilots Walter Shirra and Thomas Stafford will be able to read the "status panel"

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on the *Agena* target vehicle docking collar before moving the spacecraft in for docking.

The *Gemini-5* spacecraft will be carrying 400 lbs. of useable fuel, Conrad said. The OAMS pre-retro "burn" used during *Gemini-3* and *Gemini-4* missions will not be performed during *Gemini-5*, he said, giving them additional maneuvering fuel. However, if fuel usage is higher than budgeted for the rendezvous, they may not do the braking maneuver to save fuel for the remaining 15 experiments. If they come within several hundred feet of the pod, the rendezvous will be considered successful, he said.

• **No synthetic water**—Cooper said they do not plan to drink the water produced by the fuel cell as a by-product of hydrogen and oxygen in chemical reaction. "The water was slightly acidic, with particles floating in it, and we're not sure it would not produce ill effects," he said. "It looked fairly ghastly."

Instead, they will carry 150 lbs. of water with them into orbit and use the fuel cell-produced water to apply constant pressure around the drinking water bladder contained in the special tank. "We hope that the rate we drink the water will be at the same rate that the fuel cell will be producing its water," he said.

An attempt will be made to communicate with M. Scott Carpenter, a fellow astronaut who is participating in the U.S. Navy underwater sea-lab project off the (La Jolla) California coast. Asked what would be learned from this, Cooper said, "It would be of interest to communicate from beneath the sea to a spacecraft at orbital altitude."

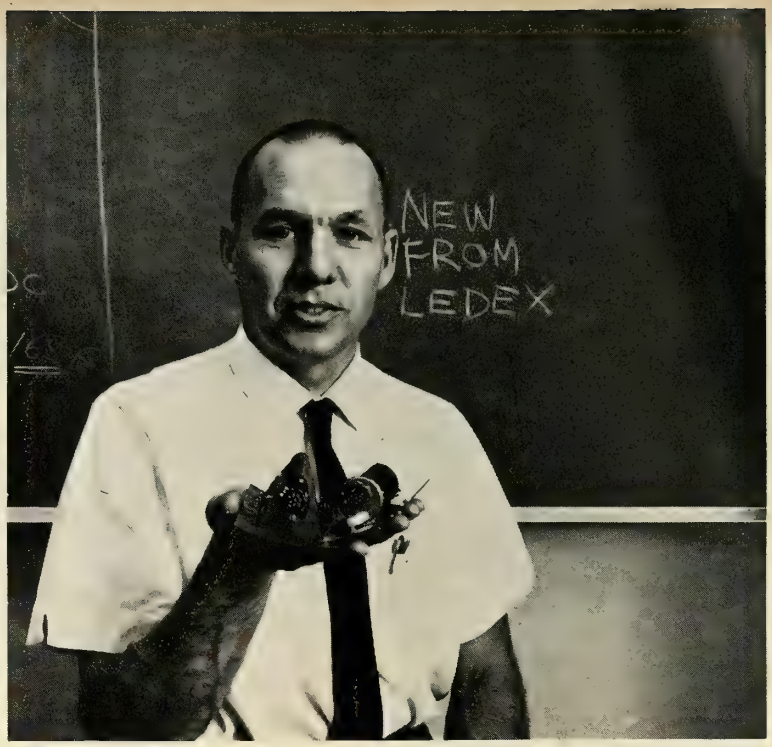
Spacecraft orbiting for extended periods of time may enclose themselves in flexible "space cocoons" for added protection against meteoroid punctures.

Britain Studies New Booster

A two-stage satellite booster is being reviewed by government officials in England as the basis for an all-British scientific satellite launching system.

Designated the *Black Arrow*, the vehicle would use engines designed by Bristol Siddeley Engines Ltd. in a frame designed by Westland Aircraft. The engines evolve from the Bristol Siddeley Gamma MK 304 rocket engine—a four-barrel hydrogen peroxide/kerosene powerplant designed to give some 25,000 lbs. thrust at sea level with specific impulse of 217.4 sec.

The Mk 304 unit has four



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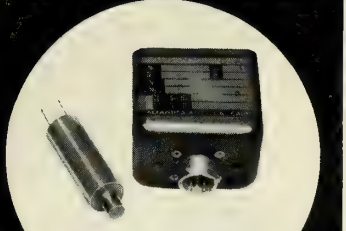

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combustion chambers individually mounted on trunnions swivelled for control about axes radial to the axis of the vehicle.

David Andrews, chief engineer for rockets at Bristol, detailed the concept at the Fifth European Spaceflight Symposium in Munich last week. The larger of the two newer engines, the BS 606, is virtually two Gamma Mk. 304 units coupled together and re-engineered to suit a motor bay of 78.8 in. diameter. This would generate a first stage thrust of 50,000 lbs.

The second engine is the BS 625, specifically designed for second- or third-stage propulsion and generating a vacuum thrust of 15,300 lbs. on the same propellant combination. All engines are turbine-fed units.

The BS 625 is a two-chambered engine using a single turbopump feeding two gimbal-mounted combustion chambers. The entire vehicle could place 200-lb. satellites in 300-mi. orbits.

Ion Engine Runs 2,610 Hours

A second-generatioin bombardment ion engine racked up some 2,610 operating hours in a simulated space environment—convincing its developers at Electro-Optical Systems that operational life will exceed 10,000 hours.

The test was conducted by EOS under a 16-month contract with NASA's Lewis Research Center. A follow-on contract has been awarded to EOS for continued lifetime testing of the cesium thrustors with larger feed system reservoirs.

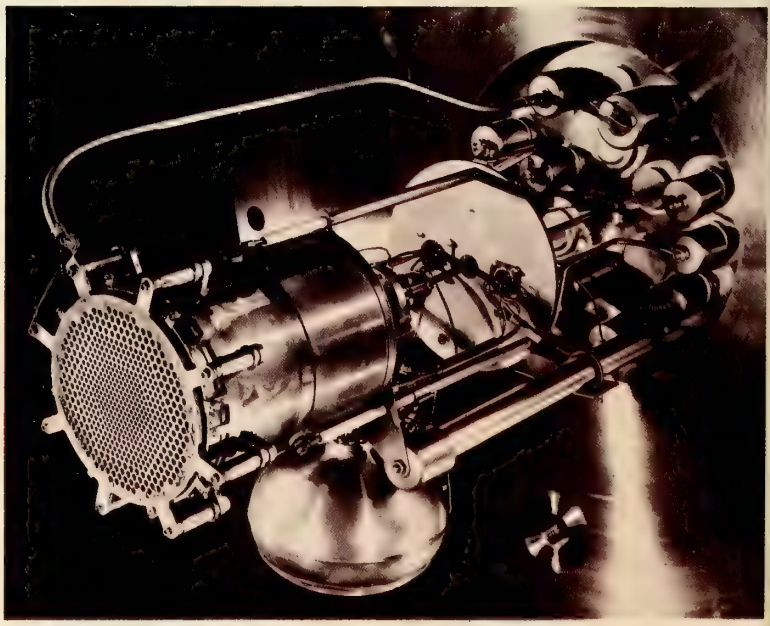
Gordon Sohl, a physicist in the Ion Physics Dept., will deliver a paper co-authored by Robert C. Speiser, assistant manager for research, and George Reid, of the physics group, at the second annual American Institute of Aeronautics and Astronautics meeting in San Francisco this week.

Dr. Elliot Katz, manager of the EOS Fluid Physics Div., told MISSILES AND ROCKETS that the recently completed test was conducted to allow three separate operative cycles of 892, 880 and 838 hours respectively.

Over 99% of the initial cesium fuel loadings in the zero-g feed systems was used up in each run. Speiser reported the engine operated without a single failure or shut-down except for refueling.

The successful endurance run indicates to EOS scientists that the lifetime of cesium thrustors can be expected to exceed 10,000 hours in actual flight conditions.

Significant improvements in beam focusing through distributed geometry of the thrustor's screen and acceleration electrodes led, in part, to the successful endurance run. Three



ELECTRO-OPTICAL SYSTEMS, INC.'S bombardment ion engine, which recently completed a record endurance run of 2,610 accumulative hours, is shown after removal from vacuum tank. Engine employs improved autocathode design and revised screen electrode geometry. Spherical tank portion of zero-g fuel feed system is beneath engine.

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Stabilizing Spheres for Apollo

A GOODYEAR Aerospace Corp. engineer inspects a sphere that will hold NASA's three-man Apollo spacecraft upright in water during recovery operations. The spheres are being developed and produced by Goodyear Aerospace under a contract from North American Aviation's Space and Information Systems Div., prime contractor for Apollo.

aperture sizes were distributed over the electrode surface—a refinement over earlier units, which used uniform-sized electrode apertures.

The cesium passed through the cathode into the discharge chamber, coating a refractory metal emitter surface. This becomes a highly efficient electron emitter maintained at operating temperatures by ion bombardment from the discharge.

● **Low energy avoids damage**—The low energy of the bombarding ions—6 to 8ev—was not sufficient to cause sputtering damage to the cathode surface.

In operation, the engine generated ions by electron bombardment of vaporized cesium fuel in the discharge chamber. The ions were then electrostatically accelerated to high velocities producing thrust. Mass utilization efficiencies over 90% were obtained in these thrustors at discharge energy expenditures of 350 to 400ev per ion while overall engine efficiencies ranged from 55% at 3,000 sec. Isp to 87% at 9,000 sec. Isp.

The long-duration-run engine was operated at a nominal design point of 7,000 sec. Isp, producing a thrust of 10 millipounds at a power-to-thrust ratio of 182 kw/lb. The thrustor used 2.3 kg of cesium per hour. Thrustor weight including the loaded 5-lb. cesium fuel system was about 10 lbs.

Acceleration electrode erosion was found to be negligible. Electrode pitting did occur but the pit depth actually indicated an erosion rate decrease with engine operation.

The present NASA contracts at EOS grew out of a 1961 company proposal for a multiple aperture gas discharge source using cesium expellant in conjunction with a cesiated cathode to achieve high mass efficiencies at reasonable source energies.

TV of GT-5 Recovery Possible

Communications Satellite Corp. has expressed a willingness to cooperate on live television coverage of the recovery of the *Gemini 5* astronauts next month—but not on the terms initially proposed by International Telephone and Telegraph Corp.

Comsat filed a statement with the Federal Communications Commission last week in response to a proposal

submitted by ITT World Communications, Inc. ITT asked the FCC for authority to provide first-time television coverage of a *Gemini* recovery operation using the *Early Bird* satellite. The plan involves establishing a transportable ground station aboard the U.S. Navy carrier Lake Champlain.

Comsat opposes the plan as presented by ITT, calling it an opening wedge for a common carrier to own a ground station. The FCC last May granted Comsat sole authority to own and operate three initial U.S. ground stations for the international satellite communications system.

However, in the national interest and because of the time factor involved, Comsat told the FCC, it would be willing to cooperate with ITT in this one instance. Comsat indicated that because of the many problems involved—including obtaining permission from European nations to pre-empt time on the satellite—ITT would be unable to carry out the program alone. The FCC is not expected to act on the matter until next week at the soonest. Reportedly, ITT has also requested approval from the Navy and NASA and is awaiting word from them.

260 Case Rupture Traced

At least two defects not detected by nondestructive testing have been blamed for the hydrotest rupture of a 260-in.-dia. solid rocket motor case last April.

The case was fabricated for Thiokol Chemical Corp. by Newport News (Va.) Shipbuilding and Drydock Co. for Thiokol's portion of the large solid-rocket demonstration program. The catastrophic failure took place at Newport News April 11.

The two defects were mentioned in preliminary findings of an investigating committee. One defect in the motor casing was significantly larger than critical size for the projected hydrotest proof pressure, and the other was approximately of critical size for its orientation. The case failure effectively ended the NASA-sponsored program at Thiokol.

The internal pressure at failure was 542 psi—or about 56% of proof pressure. Initial findings of the investigating committee pinpointed one defect as being of sufficient size and appropriate orientation to initiate failure at 542 psi. Once failure began, the other known defect provided a secondary failure origin.

● **Where located**—Both defects were located within the W7-302 longitudinal submerged arc weld or the associated heat-affected zone, lying under TIG weld repairs. The fracture origin defects were not indicated by nondestructive testing techniques either before or after the TIG weld repair. Liquid penetrant, radiography and ultrasonic inspection methods were used. No further NDT was conducted after aging of the welds.

The cases were designed by Thiokol's Space Booster Division and manufactured by Newport News. Two cases were called out in the original contract. The material specified was 18 Ni-Co-Mo-Ti maraging steel. Thiokol selected the 250 grade air-melted alloy (250,000-psi nominal yield strength).

Case design was based on a plate yield strength of 230,000 psi and a weld efficiency of 90% for a design strength in the welds of 207,000 psi. The weld safety factor of 1.3 resulted in nominal plate thickness of 0.730 in. in the cylindrical selections and 0.477 in. in the hemispherical domes.

In the weld area, a mismatch of 10% of the thickness was allowed but it was not to exceed 0.060 in. The resultant stress concentration cal-

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culated by an elastic analysis for such a mismatch in a longitudinal weld results in a local stress some 25% higher than design stresses.

All welds in the cylinder and domes were made through the submerged arc process. Each of the three subassemblies of the case were aged at 835°F for four hours. These were then joined to form the case by girth welds using the two-pass submerged arc welding procedure. The welds were then locally aged with the same heat schedule as the subassemblies.

● **Pinpointing methods**—Committee experts determined the general origin of the fracture by two independent means. One approach triangulated the output of certain accelerometers attached to the case before the hydrotest. The second method followed the chevron markings of the fracture surfaces.

Both origins were located just under patches of TIG weld repairs in one of two longitudinal welds in the aft cylindrical portion of the motor case. One origin was dubbed the "black origin" because of its color—seemingly due to heat tinting during the aging cycle. The second failure origin was called the "clean origin."

The black origin was associated with and perpendicular to the W7-302 weld. Most of its 1.5-in. length was submerged in the wall, but a small portion—5/32 in.—broke through to the outside surface of the case.

The white origin was about 2 ft. aft of the black one, completely submerged in the wall and 1.5 in. long by 1/8 in. wide.

Analysis of the fracture-propagation directions indicated that the clean origin was the primary point of failure. A secondary fracture was triggered at the black origin by the advancing crack from the clean origin.

There was no evidence of de-laminations in the maraging steel around the failure origins. In addition, the committee has not yet found any evidence of external causes in the hydroburst, although an investigation is now probing for other contributing causes.

While weld repairs had been made in the failure areas, no flaws were known to be in these regions. Newport News experts are confident the black origin would have been detected by the nondestructive test techniques employed if it had existed at the time of inspection.

The committee says the detection of the clean origin by NDT is still open to some conjecture.

The committee instigated additional investigations to arrive at a complete understanding of all the details of the failure mechanism and the sensitivity of nondestructive testing techniques.

● **Exhaustive investigation**—Other experts in brittle fracture have been invited to inspect the failure and submit their comments and opinions. Accelerometer data is being thoroughly sifted and fractography studies into the black and clean origins have been started.

Further investigations into weld repair areas on the motor case are under way and weld strengths will be probed. A two-phase program covering the NDT methods used is being performed using independently supplied cracked specimens and controls.

All longitudinal welds have been saved and stored for future investigations, although these are not directly a part of the failure investigation.

Past experience at Newport News had indicated that aging of welds should not introduce new defects. As a result, a joint decision was made by Thiokol and Newport News that nondestructive testing would not be repeated after aging of the welds had been completed.

The preliminary report detailed

Chaparral Configuration Revealed

ONE OF ITS Sidewinder heat-seeking missiles (upper left) leaves Army's Chaparral missile launcher, which is mounted on a mobile vehicle. The air-to-air Sidewinder is being adapted as part of a surface-to-air defense system for forward battle areas. Present test configurations at the Naval Ordnance Test Station, China Lake, Calif., have four missiles per launcher. Philco's Aeronutronic Div. is developing Chaparral.

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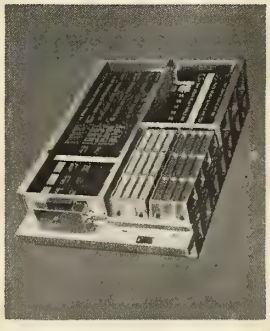

For additional information regarding Raytheon's activity in the field of advanced guidance computers, write to *Manager of Marketing, Raytheon Company, Space and Information Systems Division, Sudbury, Mass.*

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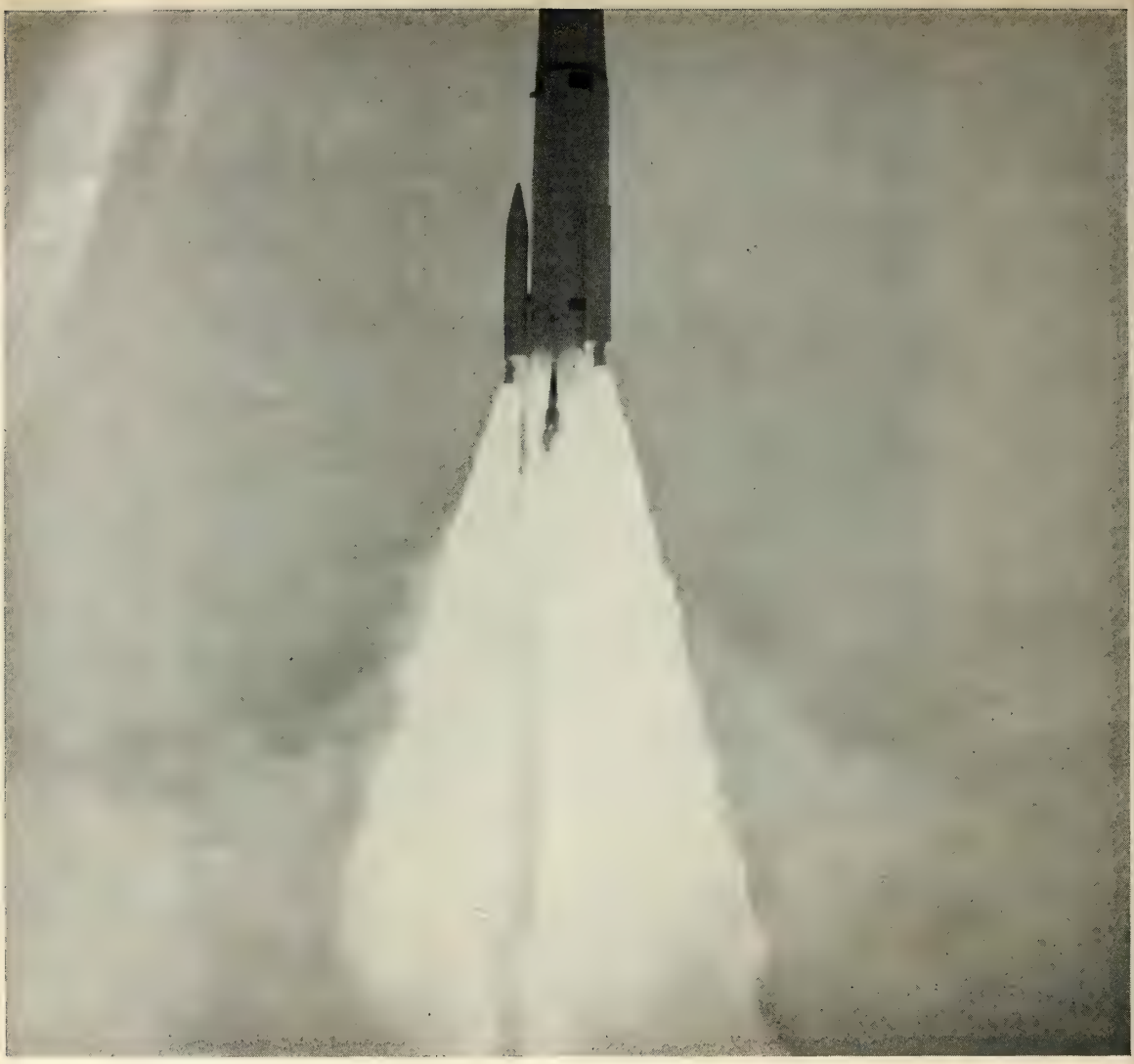

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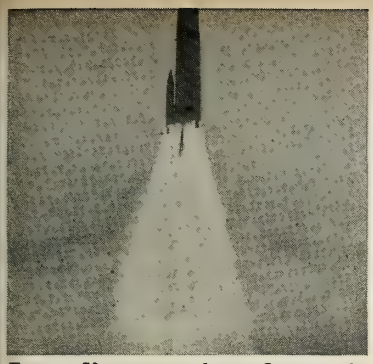

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the discovery and existence of the two failure origins. There may be others. The committee has not yet disclosed its conclusions as to the creation of the failure origins, but the type of investigations now being pursued indicate a distrust of the NDT procedures and the fabrication-inspection-repair sequences followed in manufacturing the case.

The committee consists of experts from NASA Lewis, NASA headquarters, Newport News, Thiokol, U.S. Steel, International Nickel, Ladish Co., Cameron Ironworks, Inc., USAF Rocket Propulsion Lab and the U.S. Naval Research Lab.

Apollo Systems Under Study

Project *Apollo* and the *Apollo Extension Systems (AES)* program are undergoing a 2-week review by 100 of the nation's top scientists.

At the end of the session, the scientists will recommend modifications or additions to the U.S. manned lunar exploration program. Participating in the review, which ends this week, are six of the seven working groups of NASA's Manned Space Science Coordinating Committee. Members are from U.S. universities, research laboratories and government agencies.

The groups are in the areas of geology, geochemistry/petrology, particles and fields, geophysics, bioscience, and geodesy/cartography. A group on lunar atmosphere has already completed its work.

Shots of the Week

The Soviet Union in three launches last week sent into orbit a 26,000-lb. satellite, five *Cosmos* series satellites and an interplanetary space probe (p. 11). The big *Proton I* satellite is the heaviest payload yet orbited, and was boosted by a new rocket on July 16. The five *Cosmos* satellites (numbers *71-75*) were all put in orbit on the 16th aboard a single booster. *Zond III*, the interplanetary probe, was launched on July 18 with the announced purpose of testing automatic systems in "prolonged space flight" and for holding scientific studies in "interplanetary space." The Soviet news agency Tass reported that the probe's trajectory was "close to the expected one." Because this is not a likely time for a Mars or Venus probe, it is possible that the shot is merely a preliminary test of systems for use in a possible probe of Venus next fall.

● The Air Force launched two *Nuclear Detection Satellites* and a companion *Octahedral Research Satellite* aboard an *Atlas-Agena* vehicle (see story below).

● The fourth test firing of the Army's *Lance* surface-to-surface missile system, July 21, is expected to weigh heavily in Army and DOD decisions about whether or not to develop the system for battlefield support roles. The second and third test firings proved less than encouraging because of seal failures, permitting leakage of the oxidizer into fuel areas and burnthroughs in the missile case. This problem has apparently been solved. The fourth test involved a non-self-propelled version of the system. Total weight of the LTV-developed missile and launcher is about 1½ tons and includes self-checkout equipment and all other gear needed to aim and fire the unit. *Lance* is apparently designed for transport in helicopters.

Third NDS Pair Launched

Injection into orbit was accomplished July 21 for one of twin U.S. nuclear detection satellites launched at 4:27 a.m. July 20, from Cape Kennedy.

The third pair in a planned series, the two satellites carry improved detection devices designed by the Atomic Energy Commission's Los Alamos Scientific Laboratory and new, integrated circuitry developed by Sandia Corp., Albuquerque, N.M.

After an interval of 72 hours from launch, plans called for entry of the second satellite into a similar orbit, trailing the first by approximately 150 degrees. Detection equipment in the vehicles can sense nuclear detonations and their results in an area extending from the Earth's surface to 200 million miles into space.

The twin satellites weighed 525 lb. at launch and were accompanied by a third, smaller vehicle, weighing 12 lbs. All three vehicles were inserted into a preliminary elliptical parking orbit from which the heavier twins could be placed in a more nearly circular, high-altitude orbit. Preliminary figures on the parking, or transfer, orbit showed an apogee of 60,496 n.mi. and a perigee of 105 n.mi., (105.7 n.mi. was the planned perigee) with a period of 2,591 minutes.

The small *Octohedral Research Satellite (ORS III)* will remain in this elliptical path to acquire data for comparison with the larger, 20-sided *Vela* twins. *ORS III* is designed to monitor background en-

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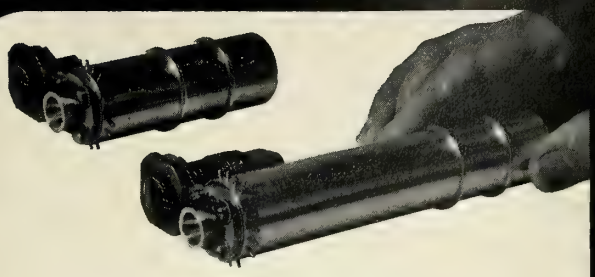

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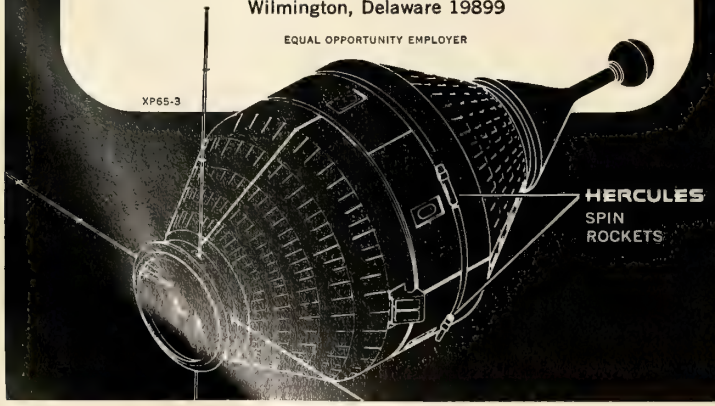

vironment in the clouds of trapped radiation particles which form belts around the Earth.

Transfer orbit apogee of 60,496 n.mi. was higher than the planned 55,203 n.mi., but Air Force and Advanced Research Projects Agency (ARPA) officials announced they were pleased with the launch.

Preliminary figures on the circular orbit into which the first *NDS* was inserted indicate apogee and perigee just above and just below 60,000 n.mi., respectively, a period of about 6,780 minutes, and an inclination of about 37 degrees.

After the *Atlas* booster performed its roll maneuver into an orbital plane with a 34.1-degree inclination, booster engines were jettisoned. The clamshell fairing, protecting the twin vehicles on their trip through the atmosphere, was jettisoned. The *Agena* vehicle's engines burned to achieve injection into orbit at 105 n.mi. and the two spacecraft were separated from the *Agena* by springs following burnout. Cold gas jets had spun the vehicles up to about two revolutions per second before their simultaneous separation from each other and from the spin apparatus.

Tandem placement of the twin vehicles in orbit, separated by between 150 and a 180 degrees, insures monitoring of both Sun and shadow sides of the Earth for radiation resulting from any nuclear detonation in space in violation of the nuclear test ban treaty with the USSR.

Four vehicles were orbited in two earlier twin launches (Oct. 16, 1963, and July 17, 1964.) Detection equipment in the second set is still functioning as planned after more than a year in space.

The system of X-ray, gamma ray and neutron radiation detectors for the first pair of satellites contained 1,067 modules, including 2,640 transistors. By comparison, the second set contained 1,214 modules and 3,105 transistors—and the ones launched last week, 1,400 modules, with 3,511 transistors and a total of 291 integrated circuits. These circuits, designed by Sandia Laboratories, reduce the size of some of the logics modules by a factor of 10.

Launches of the first two pairs of *Vela* detection satellites were during a period of minimum solar activity. Vehicles in this third pair with their improved instrumentation will have the opportunity of observing radiation under conditions of increasing Sun activity, scheduled to reach its peak during 1968.

Equipment in these newest satellites can measure X-ray intensities

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10 times greater than before. Their data, plus that supplied by the still-active first four, should provide many new answers in solar cycle research. More than 1,500 reels of data tape from the four earliest satellites have been recorded by a world-wide tracking network. Each tape is 7,200 ft. long and contains millions of separate items of data.

Martin Signs TRAP-7 Pact

The Martin Company's Baltimore Aircraft Modification Center has been awarded an Aerojet-General Corp. contract to equip a modified KC-135 jet aircraft for use in the Air Force's Terminal Radiation Program-7 (TRAP-7).

Flying its missions at 40,000 ft., the aircraft will perform airborne measurements in areas near Kwajalein Island at the far end of the Air Force Western Test Range. KC-135 crews will record data during the 20 to 30-second period in which incoming ICBMs first encounter the atmosphere at 45-mile altitudes.

Martin's Baltimore facility is already modifying a number of other KC-135's under an Air Force contract and 48 twin-jet B-57 bombers are also undergoing modification under an Air Force contract now nearing completion.

JPL To Manage Lander

Jet Propulsion Laboratory has been assigned management responsibility for the landing capsule system of the *Voyager* program. (M/R, May 3, p. 14).

Previously, NASA had assigned JPL project management responsibility for the *Voyager* spacecraft.

Republic Gets AOSO Nod

Republic Aviation Corp. has been selected for hardware development of the *Advanced Orbiting Solar Observatory (AOSO)*.

NASA said the contract will be worth approximately $60 million. It calls for Republic to furnish two flight spacecraft and a prototype. This includes final development and design, checkout, experiment integration and launch support for the 1,250-lb. *AOSO*.

Current plans call for launching the *AOSO* in 1969. It will be launched from the Western Test Range by a *Thrust-Augumented Thor-Agena* rocket. The objective of the *AOSO* is to conduct a constant search for isolated or unusual solar activity.

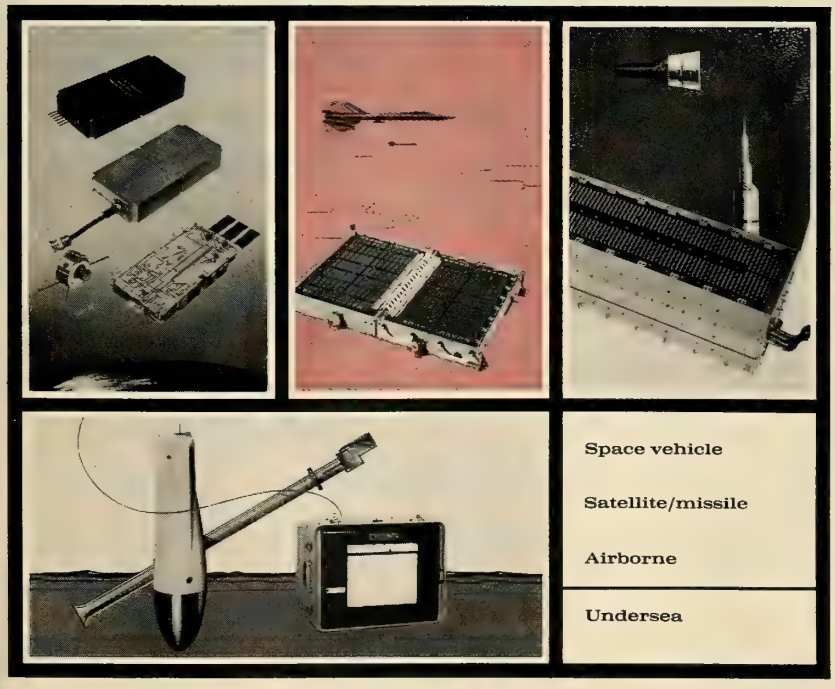
When this occurs the observatories will be capable of recording the activities with high-resolution instrumentation, assuring a better understanding of such activity and the effect upon its environment.

In addition to Republic Aviation, major subcontractors participating in the program include Honeywell, Inc., stabilization and control system, and Texas Instruments, Inc., communications and data handling system.

U.S.-German Satellite Effort Told

A U.S.-West Germany joint program to cooperate on the launching of a radiation belt monitoring satellite was announced at the Fifth European Spaceflight Symposium in Munich last week.

Max Meyer, director of the West German Dept. of Scientific Exploration of Space, told MISSILES AND



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ROCKETS in Munich that phase I of the NASA-sponsored program is under way. This consists of competition among German firms to develop the *Scout*-launched satellite.

The first launch would be from Vandenberg AFB, Calif., in 1968 as part of the currently contemplated three-satellite program. While the satellite was not named it is believed to be the *Project 625* originally proposed by the Germans to NASA.

State Systems Study Lauded

California Governor Pat Brown in Congressional testimony voiced high praise for the work done by four aerospace companies in attacking his state's social problems with systems engineering know-how (Feb. 15, 1965, p. 24).

In testimony before the Senate Labor and Public Welfare Committee subcommittee on employment and manpower, Brown said that the preliminary report on the first of the four contracts—that held by Aerojet General Corp.—is most encouraging.

Brown said, in effect, that systems engineering, as it has been used to develop space and defense projects, is a feasible approach to the problem of waste management, and in fact, the "only logical way."

The governor told the subcommittee that it is estimated in the report that California will be spending $1 billion a year by 1990 just to dispose of waste. In addition, it estimates that the pollution of California's air, land and water would then be causing about $7 billion in damage annually.

- **A first look**—Brown said that the report does not give a detailed blueprint from which the state can start immediately to build a system, nor was it intended to, since it is a feasibility study.

The California governor, who pioneered the idea of utilizing the state's vast scientific and technical resources in this manner, emphasized the basic difference between the studies of waste management already in existence, and the sort of studies being done by the systems engineering firms.

- **Waste is waste**—The systems engineering approach draws no distinction between different types of wastes, which in the past have been studied and handled separately. All related aspects of the problem have been dealt with in the current study of California's waste problems, in order to produce the single best pattern of handling all wastes, whether they be liquid, solid, or gaseous, Brown said. He added that in finding the single best solution, the system engineer would weigh economic, public health, and even social values.

It has now been proved that the aerospace engineers can handle the problem, although it is not an easy one, Brown indicated. He quoted one engineer who said, "compared with this project, *Mariner* was a snap."

- **Feasibility proved**—The Aerojet plan, he said, gives assurance that the state is on the right track, and will give a plan for moving ahead. In the space of three years, "a workable plan can be produced from which actual developments could begin," he said.

Brown pointed out that waste management facilities would be built with or without the aerospace industry, but that "the difference is that one would be more efficient than the other."

The other three contracts are: North American Aviation, transportation; Space General delinquency and crime; and Lockheed, information handling.

- **Funding**—Brown told the committee that the amounts spent in each of these contracts—$100,000—is the same as that expended in Project *Apollo* to determine how fast a capsule had to leave the Earth's gravitational pull in order to reach the Moon. However, he pointed out that the cost of embarking on such projects is very large. "Obviously, no single state has the resources to carry the burden of research and development in these areas by itself. But all of the evidence available to us at this time convinces me that the work must be done."

Brown expressed his feeling that "there is an endless list of problems to which scientists should be addressing themselves and any funds the Federal Government might invest in creating centers of science in any part of the United States would bring benefits to all Americans."

Word on MOL Winner Lags

It may be weeks before the Defense Department announces its next milestone decision in the Air Force *Manned Orbiting Laboratory* program.

In addressing the National Space Club in Washington last week, Dr. Albert C. Hall, deputy director of defense research and engineering described such a DDR&E decision as

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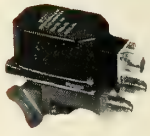

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coming "in the near future." Presumably a prime contractor would be named, plus an industry team to begin development.

Hall noted that the capability of placing 25,000 lbs. in near-Earth orbit would probably meet initial DOD requirements in the *MOL* program. Asked whether the *MOL* program will match Soviet capability demonstrated in a recent launch, Hall noted that the program isn't necessarily limited to the present payload capability of its *Titan III-C* booster. He said the *MOL* program will use the "building block" approach to growth. An increase of from five to seven segments in *Titan III* solid boosters would provide a 25% increase in payload. A substantial increase would also be provided by the use of 156-in. solid strap-ons.

Any use of the *Apollo Extension Systems (AES)* in accomplishing *MOL* goals will be determined by the extent to which *AES* meets DOD needs, Hall said. He made no other comment, except to indicate that DOD is studying this problem.

New Delta Contract Readied

NASA is negotiating with the Douglas Aircraft Co. for launch support services for the *Delta* booster.

The contract is expected to be about $12 million. The new contract will cover 15 launchings from launch sites at Cape Kennedy and the Western Test Range for a 12-month period beginning Jan. 1, 1966. It will provide for inspection and checkout, as well as the actual launch, of *Deltas* from Cape Kennedy and from NASA's new *Delta* Launch Facility at Vandenberg AFB, Calif.

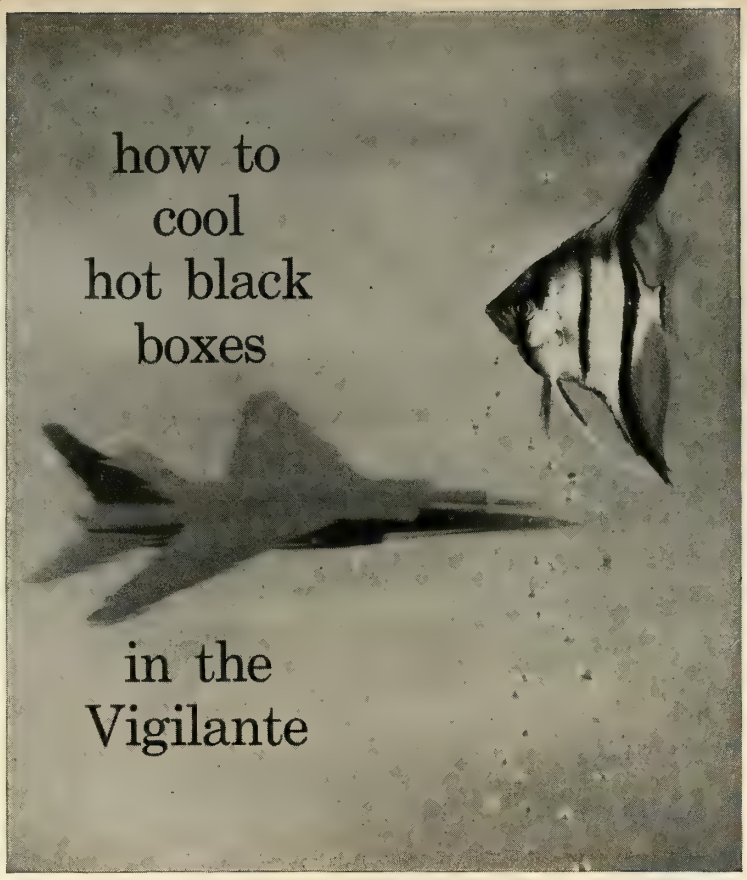
High-Altitude Solid Tested

The highest energy output ever obtained from a conventional solid propellant was demonstrated by Lockheed Propulsion Co. in a simulated altitude test firing.

The test motor used an LPC-designed ultra-high-expansion nozzle that eliminates the excessive weight and drag normally associated with such devices. The propellant consisted of a nitroplastisol loaded with beryllium powder.

The test was conducted in the altitude chamber at the Air Force's Arnold Engineering Development Center. The motor's performance exceeded that of a polycarbutene unit fired under similar conditions last year.

The work is being funded by The Rocket Propulsion Laboratory, Ed-



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wards AFB, Calif., a facility of the Research and Technology Div., Air Force Systems Command.

French Fire Three Hybrids

A series of three hybrid engines were successfully tested by the Office National d'Etudes et Recherches Aerospatiales (ONERA) last June. In the French tests, the engines were fired for 32 seconds with thrust variations of 5 to 1.

A similar hybrid was flown on April 25, 1964. ONERA spokesmen claim the units could carry a 12-lb. payload to an altitude of 100 miles with a total lift-off weight of 180 lbs. No details concerning the liquid oxygen/solid fuel performance were disclosed. Engine efficiencies were withheld, but the French are known to be working toward a tribrid engine—the ultimate in chemical propulsion.

U.S. propulsion firms claim to be ready for initial flight test work in hybrids with several flight-weight concepts already adequately ground-tested in dozens of firings. The European interest in hybrids stems in part from the fact that the systems eliminate the need for costly propellant processing plants.

Kwajalein Nike-X RFP's Due

Army is preparing requests for industry proposals, to be issued about Sept. 3, to furnish a floating power plant able to deliver intermittent net power of approximately 26 million watts to supply its *Nike-X* program test facility at Kwajalein Atoll in the Pacific Ocean.

Once industry proposals have been received and evaluated, tentative date for formal invitation for bids is Jan. 10, 1966. These invitations will be limited to bidders furnishing acceptable technical proposals.

The power plant is to be installed in a converted Navy floating drydock section and will operate unattended and remotely controlled, with its large power output precisely regulated under substantially fluctuating loads. Power-generating equipment will include both diesel engine and turbine engine prime movers, with all prime movers using diesel fuel.

ARC 'Management Slate' Wins

Atlantic Research Corp. stockholders settled a long-simmering proxy fight for control of the company (M/R, June 21, p. 43) July 10 by voting nearly two to one in favor of a slate headed by Dr. Arthur Sloan, ARC chief executive officer and board vice chairman.

The opposing faction, headed by the largest stockholder Board Chairman Dr. Arch Scurlock, was attempting to regain control of the firm. Scurlock was removed from the job of chief executive in 1962 following an inquiry into some of the firm's stock practices by the Securities Exchange Commission. His "Committee for Progressive Management" contended that the slate headed by Sloan was failing to offer enough promise for growth.

Scurlock's future with the firm remains to be resolved, but Sloan made a statement at the time of the stockholders meeting expressing the hope that Scurlock's technical talents can continue to be used for the welfare of the company without his being involved in management decisions.

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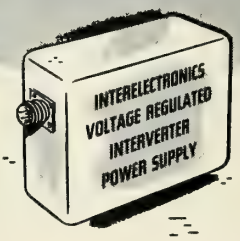

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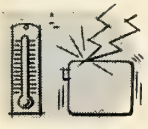

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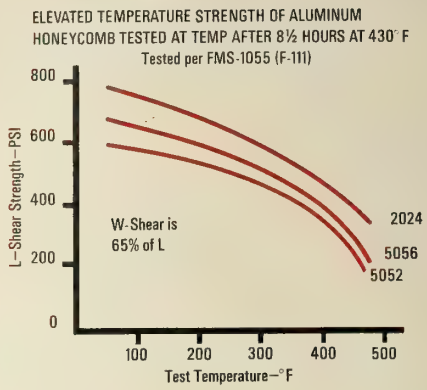

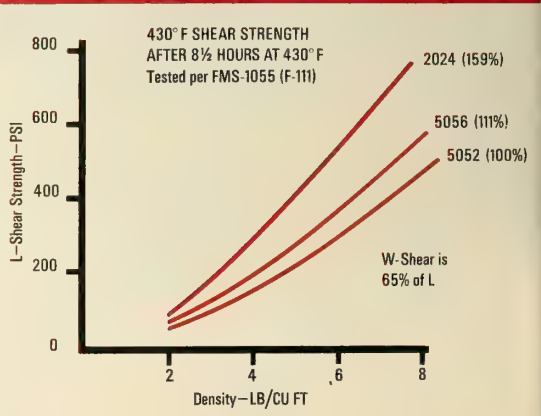

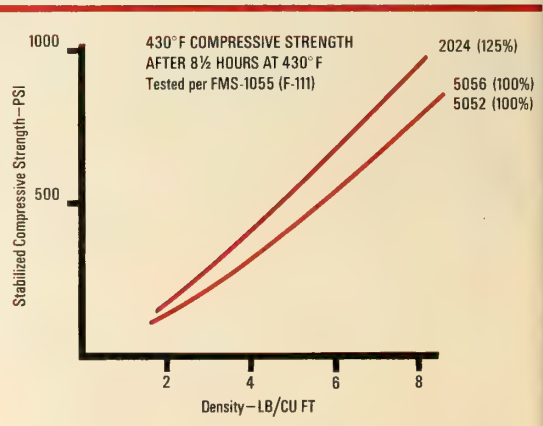

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Astronaut Edward White maneuvers in space after leaving Gemini 4 spacecraft.

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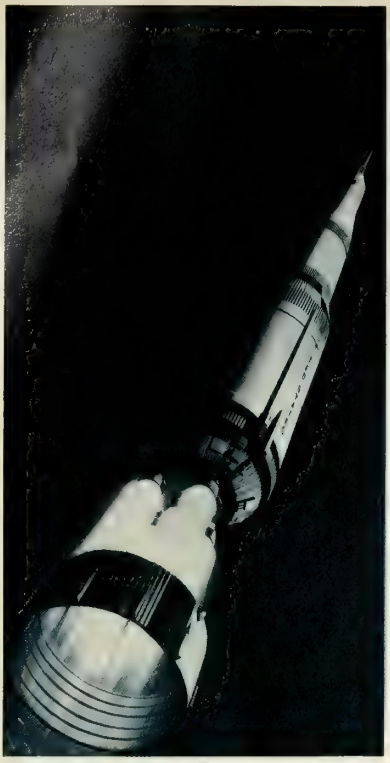

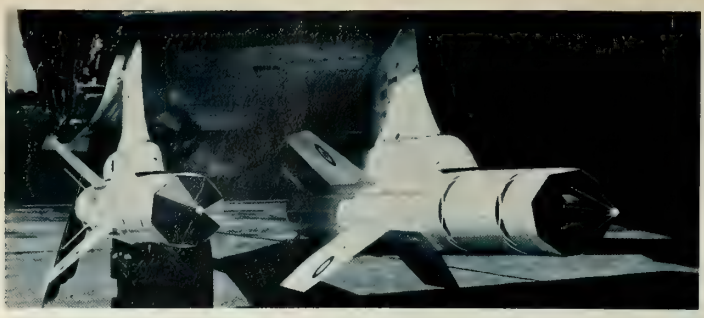

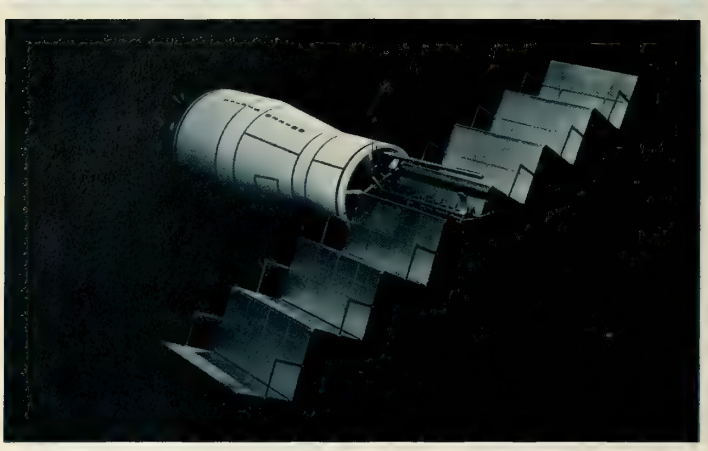

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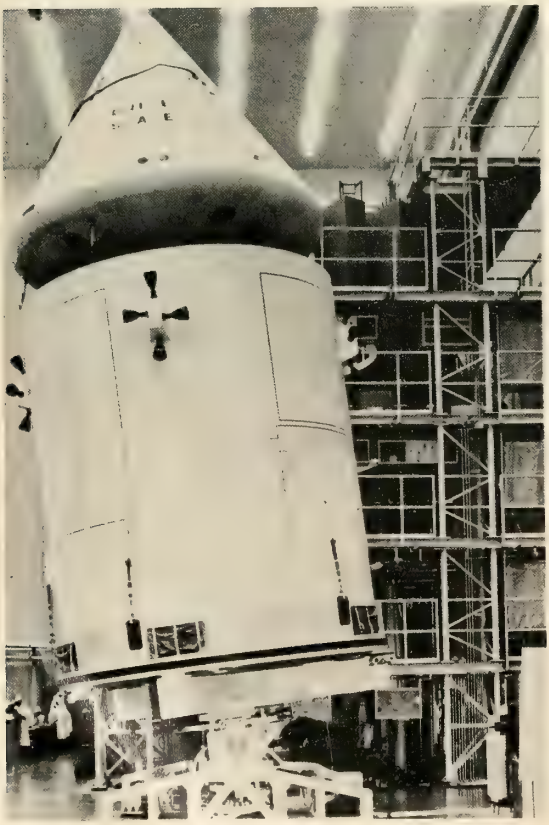


APOLLO COMMAND MODULE INTERIOR

APOLLO COMMAND & SERVICE MODULE

Apollo Command & Service Module (NASA)

TYPE: Three-man spacecraft

MISSION: Manned lunar landing

STATUS: R&D

PRIME CONTRACTOR: North American; subs: stabilization and control, Honeywell; parachute recovery, Northrop; power conversion equipment, Westinghouse

GUIDANCE: Astro-inertial with radio-inertial backup; systems management, MIT Instrumentation Laboratory; prime contractor, AC Spark Plug; associate contractors, Raytheon, Kollsman, Sperry Gyroscope

TELECOMMUNICATIONS: Collins Radio

CONFIGURATION: 3-module spacecraft; weight, 95,000 lbs.; diameter, 13 ft.; command module, 11,000 lbs., 12 ft. high; service module, 50,000 lbs., 14 ft. high; adapter, 4,000 lbs., 29 ft. high (see also Lunar Excursion Module entry)

ENVIRONMENTAL SYSTEM: AiResearch

HEAT SHIELD: Avco

AUXILIARY POWER: Fuel cell, Pratt & Whitney

PROPULSION: Escape motor, Lockheed, solid; reaction control, liquid, Marquardt; service module propulsion, Aerojet-General, liquid

BOOSTER: Saturn I, Saturn IB and Saturn V

REMARKS: First lunar landing planned for 1969, but slippage into 1970's is possible; Earth-orbit tests of boilerplate Apollo started in 1964; first three-module flight slated for 1966, with first manned flight scheduled for 1967 with Saturn IB; lunar orbital flight may precede first landing

Apollo Extension Systems (NASA)

TYPE: Manned spacecraft

STATUS: Study

MISSION: Extended Earth orbital flights up to 45 days, lunar orbit flights of 28 days and lunar surface operations up to 14 days

CONTRACTORS: No prime selected; many study contracts awarded

DESCRIPTION: Apollo spacecraft would be modified to provide extended life support and battery capability; two tanks would be removed from the service module propulsion section to provide room for additional consumable supplies; ascent stage of Lunar Excursion Module (LEM) for extended operations in lunar orbit and on the lunar surface; many experimental payloads have been proposed, including orbiting telescopes, survey, mapping, communications and many others

BOOSTER: Saturn IB and Saturn V

REMARKS: RFP for preliminary program definition for the payload integration work is imminent from the Manned Spacecraft Center; later it is expected that Marshall Spaceflight Center will be given responsibility for lunar surface operations; twenty flights are planned beginning in late 1968

ASSET (Air Force)

TYPE: Non-orbital research vehicle

MISSION: To test various materials combinations for applicability to lifting body re-entry

STATUS: Completed

PRIME CONTRACTOR: McDonnell

CONFIGURATION: Aerothermodynamic/Elastic Structural Systems Environmental Tests vehicle; delta-shaped: two versions, weighing 1,100 lbs. (4 vehicles) and 1,200 lbs. (2); length, 68.7 in., span 58.9 in.

GUIDANCE CONTRACTOR: Honeywell

BOOSTER: Atlas

REMARKS: First shot in September, 1963; more than 100 channels of data telemetered during each test flight; sixth and last launch Feb. 23, 1965; one of these vehicles recovered but will apparently not be re-flown. Expanded program to investigate lifting body re-entry over broader range of flight regimes and materials is being formulated to take up gap created by X-20 cancellation; ASSET is part of the START (systems technology for advanced re-entry test) program

(Project) Fire (NASA)

TYPE: Re-entry probe

MISSION: To measure environmental heating conditions at lunar-return speeds (25,000 mph)

STATUS: Completed

LAUNCH VEHICLE: Atlas D, plus Antares II A-5 (re-entry booster)

PRIME CONTRACTORS: Re-entry package, Republic; velocity package, Ling-Temco-Vought; launch vehicle and systems integration, General Dynamics/Convair

REMARKS: Re-entry package instrumented to define total heating and radiactive components of the re-entry environments for lunar return speeds; first flight April, 1964, successful; second flight on May 22, 1965, also successful; program now complete

Gemini (NASA)

TYPE: Two-man spacecraft

MISSION: Carry two men on orbital flights lasting up to two weeks; test orbital rendezvous feasibility

STATUS: R&D

PRIME CONTRACTOR: McDonnell

HEIGHT: 18.7 ft.

WEIGHT: Approximately 7,000 lbs.

GUIDANCE: Guidance integration, IBM; rendezvous radar, Westinghouse; spacecraft, all-inertial, Honeywell

PROPULSION: Spacecraft, Rocketdyne

ENVIRONMENT SYSTEM: AiResearch

FUEL CELL: GE

POWER: Batteries and fuel cell

BOOSTER: Titan II; Agena will be used during rendezvous missions; Atlas will launch Agena into orbit

REMARKS: 12 flights scheduled for 1964 to early 1967—first flight, unmanned, April 8, 1964, was successful; GT-2 successful on Jan. 19, 1965; first manned three-orbit flight accomplished on March 23, 1965; four-day manned flight, including first U.S. extravehicular activity, achieved in GT-4 June 3-7, 1965; GT-5 scheduled for August; GT-6 for October, and GT-7 for January, 1966

Hypersonic Research Vehicle (Air Force, NASA)

TYPE: Manned spacecraft capable of Earth-orbit-and-return

STATUS: Study

PRIME CONTRACTOR: GE, Pratt & Whitney and Marquardt selected for conceptual and preliminary design of ramjet research engine which will be test-flown on X-15 in early 1968

PERFORMANCE: To be capable of accelerating to orbital speeds from a horizontal or vertical launch

PROPULSION SYSTEM: Turbofan, Mach 0.3; ramjet, Mach 3-8 or 10 (oxygen liquified during this cycle); Mach 8-10, rocket (LH_2-LOX)

REMARKS: Funded by both AF and NASA as a joint research project, system holds most interest for AF as an operational vehicle; NASA funding is for $5 million for FY '66

Lifting Body Research Vehicles (HL-10, M-2, SV-5) (NASA & AF)

TYPE: Manned and unmanned re-entry vehicles

STATUS: R&D

CONTRACTORS: M-2 and HL-10, Northrop Norair Div.; SV-5, Martin Co.

DESCRIPTION: All three vehicles are part of DOD/NASA effort to gather data on the optimum design of re-entry vehicles which will permit controlled manned landings; M-2 and HL-10 are gliders which will be dropped from B-52 bombers and landed by men; the M-2 will carry two 500-lb. thrust rockets to use to prolong its glide if necessary; the HL-10 will have two 200-lb. thrust rockets; SV-5 will be funded at a rate of $37 million in FY'66; it will be launched by an Atlas booster and will re-enter the atmosphere at a speed of 17,-500 mph; parachute recovery is planned

REMARKS: NASA glide flights of the M-2 and HL-10 with both NASA and Air Force pilots at the controls will begin in 1965-66; unmanned flights of the SV-5 from the Western Test Range will begin in 1966; seven flights are scheduled

LORL (Large Orbiting Research Laboratory) (NASA)

TYPE: Large manned space station

MISSION: Carry 30 or more men on Earth-orbiting missions lasting one to three years; could also be used as an assembly point for manned planetary flights

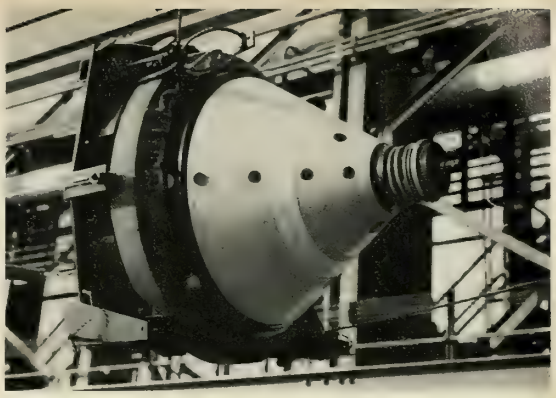
CONFIGURATION: Three-radial module with central hub that can be rotated to simulate zero g; diameter, 150 ft., weight, 247,000 lbs., volume, 67,000 cu. ft.

STATUS: Study

CONTRACTOR: Spacecraft study contract, Lockheed; many other studies awarded

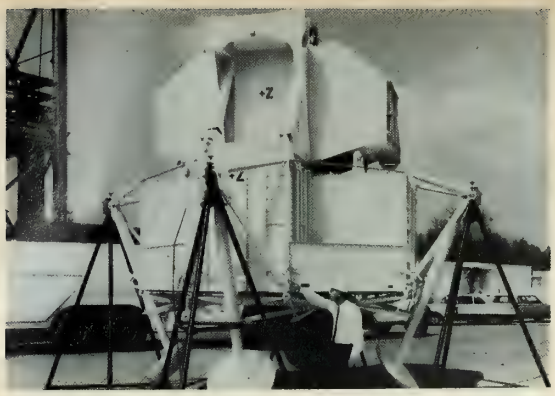
BOOSTER: Saturn V or other large boosters

REMARKS: Hardware development delayed until 1970's



FIRE

GEMINI



Lunar Excursion Module (LEM) (NASA)

TYPE: Two-man spacecraft serving as third module of the Apollo spacecraft

MISSION: Land two men on Moon, then rendezvous with orbiting Apollo

STATUS: R&D

PRIME CONTRACTOR: Grumman

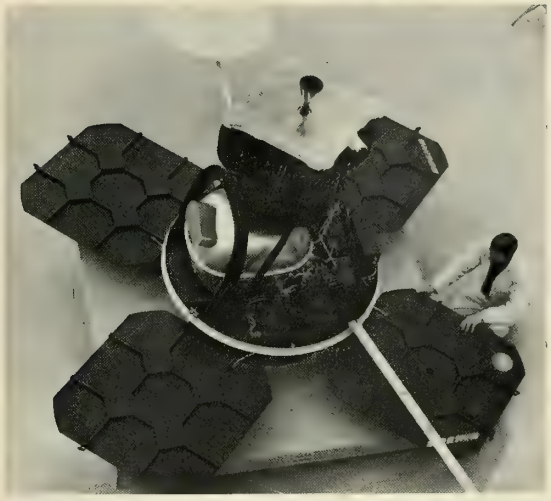
WEIGHT: 30,000 lbs.

PROPULSION: Lunar descent, TRW Systems Group; ascent engine, Bell Aerosystems; reaction control, Marquardt; environmental control, Hamilton Standard; guidance, MIT; radar and communications equipment, RCA; TMC, telemetry, Radiation, Inc.; fuel cell, Pratt & Whitney; external visual display, Farrand Optical

POWER UNITS: Batteries

BOOSTER: Saturn IB for Earth-orbital missions; Saturn V for lunar-landing flights

REMARKS: Eleven flight vehicle and nine engineering models ordered; first three-module Apollo flight scheduled for 1966, with first lunar landing planned for 1969, but slippage into 1970's possible



Lunar Logistics System (NASA)

TYPE: Unmanned spacecraft

MISSION: Land supplies on the Moon in support of Project Apollo or as a logistics carrier in the construction of a lunar base

STATUS: Study

DESCRIPTION: Two possible configurations are under study: modified Lunar Excursion Module (LEM) of the Apollo spacecraft would provide a 7,000-lb. payload capacity; specially developed lunar logistics system weighing 90,000 lbs. would land a 25,000-lb. payload on the Moon

PRIME CONTRACTOR: None

BOOSTER: Advanced Saturn

REMARKS: Program decision delayed until 1966, with no funding expected before FY '67; LLV will serve as the basic supply vehicle for such lunar base concepts as LESA (Lunar Exploration System for Apollo) and ALSS (Apollo Logistic Supply System); LESA would maintain three men on the Moon for 90 days; ALSS would keep two men on the Moon for 14 days

LEM

LUNAR ORBITER

MARINER

Lunar Orbiter Photo Craft (NASA)

TYPE: Unmanned spacecraft

MISSION: 835-lb. spacecraft to take pictures of the Moon's surface as well as radioactive and geodetic measurements over 3,700-sq. mi. area during each mission

STATUS: R&D

CONTRACTOR: Prime, Boeing; power and communication, RCA; cameras, Eastman Kodak; maneuvering engine, Marquardt

BOOSTER: Atlas-Agena

REMARKS: Five flights scheduled beginning in mid-1966; first spacecraft scheduled for delivery to Cape Kennedy in May, 1966

Mariner (NASA)

TYPE: Unmanned interplanetary spacecraft

MISSION: Scientific exploration flights to the vicinity of Mars and Venus; advanced version also under development

STATUS: R&D

PRIME CONTRACTOR: Jet Propulsion Laboratory

CONFIGURATION: 1964 Mariner weighed 570 lbs.; Mariner IV weighed 575 lbs.

INSTRUMENTATION: Instruments will change from mission to mission; first Venus spacecraft, Mariner II, had radiometers, magnetometer, radiation counters and cosmic dust detector; first Mars spacecraft, Mariner IV, had television, magnetometer, radiaton counters and cosmic dust detector

BOOSTER: Atlas-Agena

REMARKS: Successful Venus fly-by accomplished December, 1962; Mariner III flight to Mars on Nov. 5, 1964, was unsuccessful when the shroud failed to eject shortly after launch and communicatons with the spacecraft were lost; Mariner IV was successfully launched Nov. 28, 1964, and passed within 6,118 mi. of Mars July 14, 1965; TV camera transmitted to Earth the first close-up pictures of the Martian surface; nine pictures received by July 19, with 12 more scheduled to follow; other experiments aboard Mariner indicated that Mars surface pressure is probably 10-25 millibars, that there is no radiation belt around the planet, and that there is no evidence of large amounts of micrometeorites around Mars

MOL (Manned Orbiting Laboratory) (Air Force)

TYPE: Two-man spacecraft

STATUS: Pre-program definition

MISSION: To establish military usefulness of man in space

PRIME CONTRACTOR: None; preliminary design studies awarded to Boeing, Douglas, GE and Lockheed now complete

CONFIGURATION: Gemini-B capsule atop 10-ft.-dia., 20-ft.-long lab canister "about the size of a small house trailer"; lab weight estimated at 8,000 lbs. with total MOL weight of 18-20,000 lbs.; lab will be divided into three sections: a crew compartment, work area (both pressurized) and unpressurized area for experiments and equipment; capability of maintaining crew for 30 days in a shirt-sleeve environment

ORBIT: Approximately 300-mi. orbit planned with launch from Eastern Test Range

BOOSTER: Titan III-C

REMARKS: AF hopes to award development contract in summer of 1965; first unmanned Gemini flight early 1966; unmanned MOL launch late 1967; manned MOL launch first half 1968; rendezvous capability may be introduced later, but probably not during first two years of development program. DOD officials stress that it is experimental, not operational system; $150 million in FY '66 funding requested

MORL (Manned Orbiting Research Laboratory) (NASA)

TYPE: Manned space station

MISSION: Carry four to six men on space station flights lasting up to one year

CONFIGURATION: Cylindrical structure with 8,000-cu.-ft. volume; weight, 28,000 lbs.; other configurations also being studied

STATUS: Study

CONTRACTOR: Study contract, Douglas; many other system studies being made

BOOSTER: Saturn IB

REMARKS: Development is not expected to get a go-ahead until late in this decade; if approved, flights would begin in 1973-75

Pioneer (NASA)

TYPE: Unmanned interplanetary probe

MISSION: 140-lb. spin-stabilized spacecraft to obtain information about interplanetary environment and send data back to Earth at distances up to 60-90 million miles

STATUS: R&D

PRIME CONTRACTOR: TRW Systems Group

BOOSTER: Thrust-Augmented Delta

REMARKS: First of four flights in late 1965; orbits range from 0.8 au to 1.2 au for 6-month lifetime; Extended Pioneer under study

Project Scanner (NASA)

TYPE: Unmanned scientific probe

MISSION: To measure the natural radiation gradients that define Earth's horizon as seen from space vehicles in several bands of the electromagnetic spectrum, and the altitude relationship of these gradients to the solid Earth horizon

STATUS: R&D

CONTRACTORS: Spacecraft fabrication and integration, Honeywell; star-mapper telescope, Baird-Atomic; dual radiometers, Hughes Aircraft Santa Barbara Research Center

REMARKS: Each spacecraft will contain dual radiometers giving high-resolution data in at least two spectral regions; the spacecraft will also incorporate a star-mapper telescope so that the spectral data will be Earth-referenced; flights to begin in late 1965

Ranger (NASA)

TYPE: Lunar hard-landing spacecraft

MISSION: 300-lb. instrumented capsule rough-lands on Moon; before impact, TV cameras take pictures of lunar surface

STATUS: Completed

PRIME CONTRACTOR: JPL, prime; Aeronutronic, capsule; Hercules, retrorockets; Northrop, support contractor

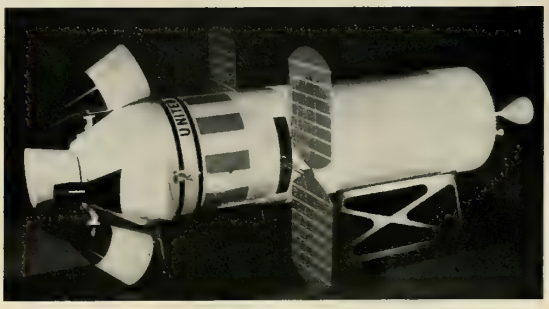
INSTRUMENTATION: TV cameras, seismometer

POWER UNITS: Solar cells

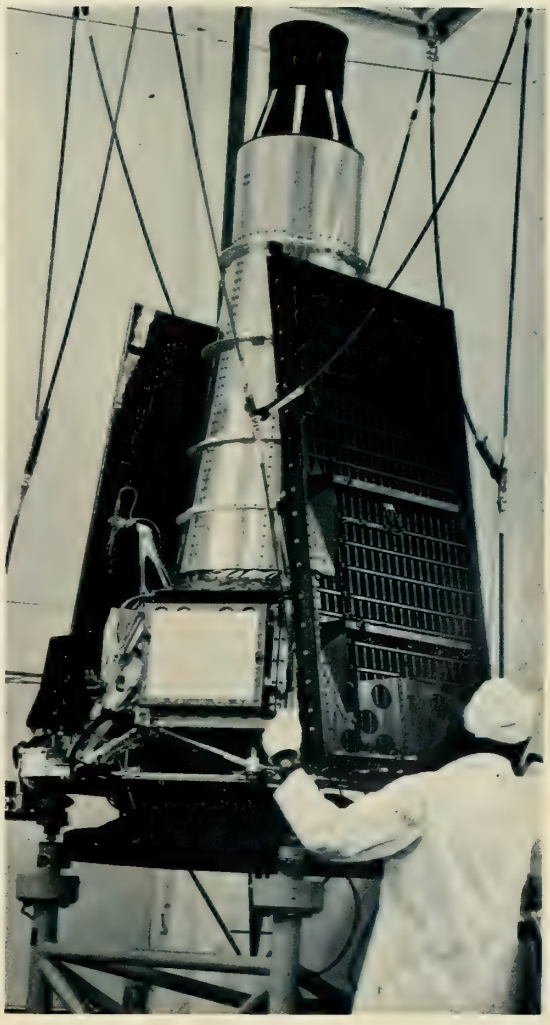
BOOSTER: Atlas-Agena

REMARKS: First six flights were unsuccessful; Ranger VII launched July 28, 1964, impacted on Moon after transmitting 4,316 pictures; Ranger VIII launched Feb. 17, 1965, returned more than 7,000 pictures; Ranger IX launched March 21, 1965, sent back 5,814 photos; program now complete

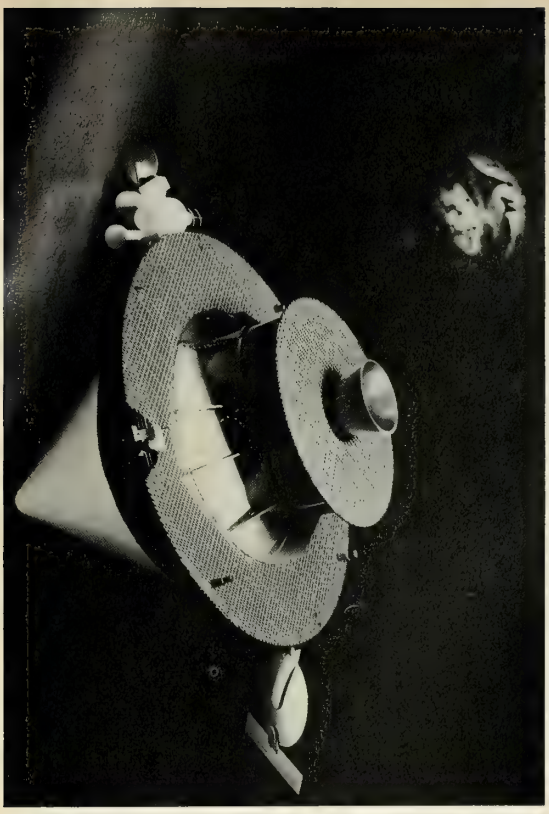
MOL



MORL



RANGER



SERT (NASA)

TYPE: Ballistic trajectory test vehicle

MISSION: Study of ion engine beam neutralization problem

STATUS: R&D

PRIME CONTRACTOR: Radio Corp. of America (SERT I)

REMARKS: First flight made on July 20, 1964; verified ion beam neutralization in space; SERT I tested two engines: one, developed by the Lewis Research Center, with a thrust of 0.00637 lbs. and specific impulse of 4,900 sec., is an electron bombardment engine using mercury as a propellant; other, developed by Hughes, is a contact ionization engine using cesium as a propellant; weighing 0.001 lb. and having a specific impulse of 8,050 sec.; SERT II and III now under study

Voyager (NASA)

TYPE: Unmanned planetary spacecraft

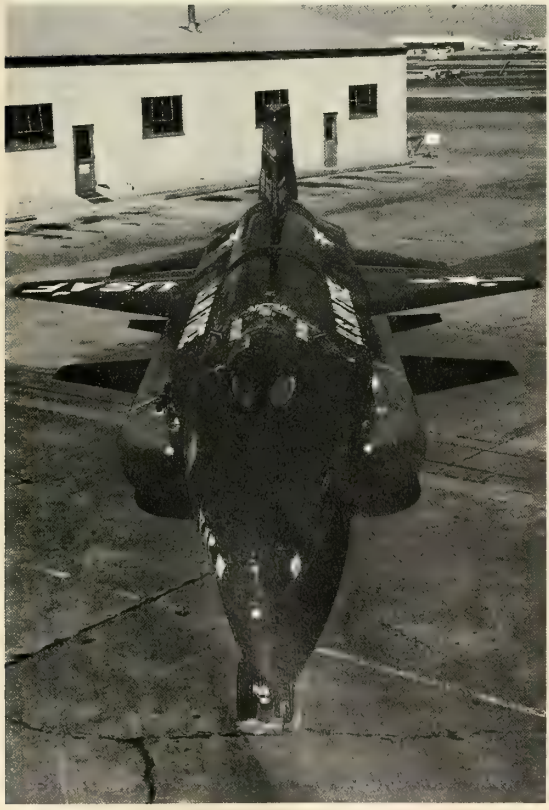
MISSION: Unmanned Mariner follow-on to orbit Mars and Venus and to eject a capsule to the surface; payload will total about 12,000 lbs.; and landing capsule about 6,000 lbs. each

STATUS: Study; will move to R&D later this year

PRIME CONTRACTOR: None; parallel pre-program definition study contracts of spacecraft bus by GE, Boeing and TRW Systems Group; one of three will be selected for program definition later this year; RFP's for preliminary study of landing capsule will be issued after Sept. 1, 1965

INSTRUMENTATION: Not determined

BOOSTER: Voyager will be launched by Saturn IB/Centaur; test flights of booster and spacecraft will be made in 1969; first Mars flights planned for 1971, and Mars and Venus flights will be made throughout the 1970's; hardware funding will be included in the FY '67 budget



Surveyor (NASA)

TYPE: Lunar soft-landing spacecraft

MISSION: soft-land 2,150-lb. spacecraft on the Moon; last nine spacecraft will weigh 2,500 lbs. and will include a small roving vehicle which will move over the surface

STATUS: Development

PRIME CONTRACTOR: Hughes

INSTRUMENTATION: 100-300 lbs. of scientific instruments including stereo panoramic TV, X-ray diffractometer, surface sampler, touchdown dynamics, micrometeorite experiment

BOOSTER: Atlas-Centaur; uprated Atlas SLV-3X used for later flights

REMARKS: First of four engineering test flights scheduled late this year; it will be followed by three operational missions; nine other heavier spacecraft will be launched beginning in 1967

X-15 (NASA, Air Force)

TYPE: Manned rocket airplane

MISSION: To provide data on hypersonic flight and serve as research craft for experiments related to space and aeronautical sciences

STATUS: R&D flight-testing

PRIME CONTRACTOR: North American

AIRFRAME: System contractor, North American; length 50.2 ft.; launch weight, 33,400 lbs.; landing weight 14,500 lbs.; wingspan, 22.4 ft.

GUIDANCE: Inertial flight data system, Sperry Gyroscope; adaptive flight control system, Honeywell

AUXILIARY POWER UNITS: System contractor, GE

ENGINE: System contractor, Thiokol; propellant, liquid ammonia; oxidizer, liquid oxygen

THRUST: 57,000 lbs. total from Thiokol Type YLR-99

REMARKS: Plane No. 3 set altitude record of 354,200 ft. Aug. 22, 1963; plane No. 1 set speed record for manned power flight of 4,104 mph on June 27, 1962; X-15-2 modified for Mach-8 flight by addition of external tanks (launch weight increased to 50,914 lbs.); will also be used as a test bed for ramjet engines with flights in 1968

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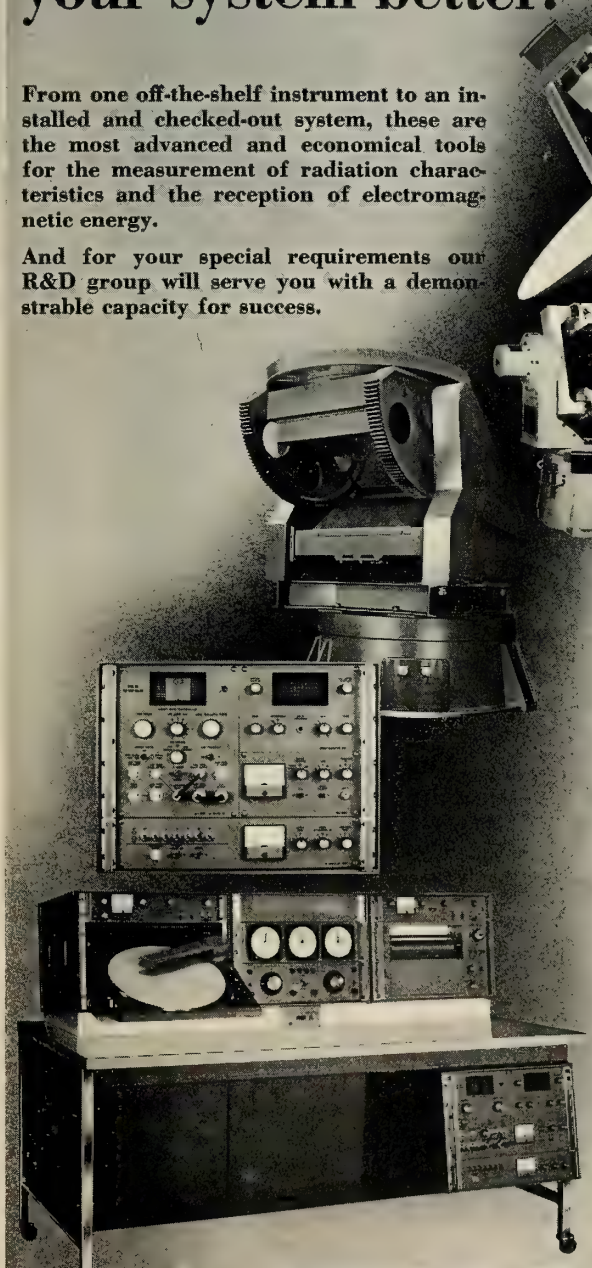

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Applications Technology Satellite (NASA)

TYPE: Unmanned scientific satellite

MISSION: 780-lb. satellite to flight-test communication and meteorological equipment at medium and synchronous orbit; it will serve as a test bed for a gravity-gradient experiment

STATUS: R&D

PRIME CONTRACTOR: Hughes

BOOSTER: Atlas-Agena

REMARKS: Program calls for five satellites with the first launch scheduled for 1966; to test a gravity-gradient experiment; two later flights will be into medium orbits, and two flights will be made in synchronous orbit

ANNA 1B (Army, Navy, Air Force)

TYPE: Geodetic research satellite

MISSION: Measure strength and direction of Earth's gravitational field, mark positions on its surface, and locate its center of mass

DEPLOYMENT: Studies made with optical and doppler systems; doppler data still being acquired. (ANNA 1A failed to orbit)

PRIME CONTRACTOR: Johns Hopkins Applied Physics Lab

BOOSTER: Thor-Ablestar

FRAME: Spherical, 36 in. dia.; 350 lbs.

INSTRUMENTATION: Four 8-million-candle-power flashing lamps developed for the Air Force; two doppler transmitters broadcasting continuously at 162-324 mc and 54-216 mc; digital clock that provides timing markers as phase modulation on two doppler frequencies; radio-ranging system with three frequencies used for phase comparison measurements in the UHF-VHF range; 47.6-in. belt of solar cells, silver-painted spiral band antenna

ARS (Aerospace Research Satellite) (Air Force)

TYPE: Scientific satellite

STATUS: Development

MISSION: To provide a low-cost scientific research vehicle for re-entry, probe and satellite missions

PRIME CONTRACTOR: General Dynamics/Convair

CONFIGURATION: A pod mounted on the side of an Atlas booster; length, 55 in.; diameter, 27 in.; weight, 300 lbs. (200-lb. payload); equipped with solid engine to provide impulse after separation from booster

ORBITS: Depending on payload weight, can be placed in orbits varying from 500 to 2,000 n. mi.; as a re-entry vehicle, attains speeds of up to 30,000 fps

GUIDANCE CONTRACTOR: General Dynamics/Convair

GUIDANCE: Strap-down system with three orthogonally mounted gyros for displacement and rate data during flight; once in orbit, satellite is unstabilized

BOOSTER: Atlas

REMARKS: Seven vehicles being built under present contract with Office of Aerospace Research. Pods of ARS type have been flown on 44 missions

Biosatellite (NASA)

TYPE: Unmanned scientific satellite

MISSION: Test effects of spaceflight on various plant and animal life forms, including primates, for periods of 3 to 30 days

STATUS: R&D

PRIME CONTRACTOR: GE

BOOSTER: Thrust-Augmented Delta

REMARKS: Six 1,000-lb. satellites scheduled with first launch expected late in 1965; 14 experiments chosen for Biosatellite-A

Discoverer (Air Force)

DESIGNATION: Program 622A

MISSION: Military satellite test-bed

STATUS: Operational

PRIME CONTRACTOR: Lockheed, overall; GE, re-entry vehicle; Bell Aerospace, propulsion

PERFORMANCE: Variable orbits, depending on mission; multi-restart engine gives considerable latitude

CONFIGURATION: Uses Agena-series satellites; initial configuration—length, 19.2 ft.; diameter, 5 ft.; weight, about 1,700 lbs.; all dimensions except diameter increase ⅓ to ½ depending on payload

BOOSTER: Thor or Atlas with Agena upper stage

RE-ENTRY VEHICLE: GE-designed, capsule type, 27-in. length, 33-in. diameter, weight about 300 lbs.

REMARKS: Data on program now classified; used for testing space effects on bioastronautic specimens, materials and equipment; indications are that cheaper methods are now being used to launch these payloads and the Discoverer program has been greatly reduced

Early Bird (HS-303) (Comsat Corp.)

TYPE: Communications satellite

MISSION: To obtain information for design of commercial system and provide operational experience

STATUS: Operational

CONFIGURATION: Modified Syncom designed to provide up to 240 two-way voice channels

PRIME CONTRACTOR: Hughes Aircraft Co.

BOOSTER: Thrust-Augmented Delta

REMARKS: Early Bird I successfully launched April 6, 1965, into synchronous orbit over the Atlantic; commercial operation initiated June 28; second Early Bird ready for possible launch later this year; third satellite now being assembled; contracts expected to be let this fall for advanced communications satellite systems with 1,000 to 1,200 voice channels; possibly a completely synchronous system or a combination of synchronous and medium-altitude phased array using a "universal satellite" which could be placed in either position; full commercial operation expected by end of 1967

Echo (NASA)

TYPE: Inflated balloon passive communications satellite

MISSION: Reflect radio signals off large (100 ft., Echo I; 135 ft., Echo II) inflatable spheres in circular orbits (890 mi., Echo I; 725 mi., Echo II)

STATUS: All launches complete

PRIME CONTRACTOR: NASA

FRAME: Mylar plastic and aluminum foil laminate, Echo II; aluminized Mylar, Echo I

INSTRUMENTATION: Tracking beacons on sphere

POWER UNITS: Batteries and solar cells

BOOSTER: Thor, Thor-Delta and Thor-Agena

REMARKS: Echo I in orbit since Aug. 12, 1960; two ballistic shots were conducted from AMR—first Jan. 15, 1962 (sphere ruptured), second July 18, 1962 (sphere inflated safely but was underpressured); Echo II launched Jan. 25, 1964, from PMR in polar orbit, 642 to 816 mi.; no more launches scheduled

GEOS Satellite (NASA)

TYPE: Geodetic satellite

MISSION: Provide a triangulation point in space for determining distances and positions on Earth; continue geodetic measurements of Earth

BOOSTER: Delta (improved)

STATUS: R&D

PRIME CONTRACTOR: Johns Hopkins University's Applied Physics Lab. for Goddard Space Flight Center

FRAME: Octahedron topped by a truncated pyramid; weight 350 lbs.

INSTRUMENTATION: Flashing light beacon; range and range rate transponder; Doppler beacon; radio-ranging transponder; Minitrack beacon; satellite clock; corner reflector for laser beam measurements

REMARKS: First launch in last half of 1965

Initial Defense Communications Satellite (Air Force)

DESIGNATION: Program 369

TYPE: Military communications satellite

STATUS: Early development

PRIME CONTRACTOR: Philco/TRW Systems Group—Program definition studies

PERFORMANCE: Will orbit at 6,000 mi.; polar; multiple-launch (in series of 6-8) active repeater; 24-36 satellites in orbit simultaneously; weight less than 100 lbs.; placed in planes 45 degrees apart

PAYLOAD: Narrow bandwidth voice and teletype equipment; anti-jamming equipment

BOOSTER: Atlas-Agena

SUPPORT EQUIPMENT: Expected to use Advent stations at Fort Dix, N.J., and Camp Roberts, Calif., and mobile ground stations developed by Hughes

REMARKS: Management responsibilities: interface problems, Defense Communications Agency; satellite system, AF; ground installations, Army; program definition complete; High-Altitude Synchronous system shelved for now

Nimbus (NASA)

TYPE: Second-generation weather satellite

MISSION: 900-1,000 lb. satellite in 500-mi. near-polar Earth orbit

STATUS: R&D

PRIME CONTRACTOR: Goddard Space Flight Center; integration and testing, GE

INSTRUMENTATION: RCA vidicon cameras for cloud data; radiation sensors at various resolutions and spectral ranges for heat balance, temperature and cloud cover; automatic picture transmission system; high resolution infrared radiometer (nighttime cloud-cover pictures); advanced vidicon camera system

POWER UNITS: Solar cells and batteries

BOOSTER: Thrust-Augmented Thor-Agena

REMARKS: First launching successful on Aug. 28, 1964; picture and IR quality good in spite of satellite's elliptical orbit; transmission stopped on Sept. 29, 1964; second satellite launch scheduled for 1966; third, 1967; and fourth in 1968-69

Explorer (NASA)

TYPE: Unmanned scientific satellites

MISSION: To explore the atmosphere, ionosphere, magnetosphere and near-Earth region of interplanetary space with satellites specifically designed for each special mission and to provide cooperative in-flight space research opportunities for the international scientific community; orbits vary widely

STATUS: Both R&D and study

PRIME CONTRACTOR: Changes from mission to mission

CONFIGURATION: Designs vary greatly in size and shape depending on mission requirements

INSTRUMENTATION: Instruments vary according to needs of particular mission

BOOSTER: Scout, Delta and Thor-Agena

REMARKS: Twenty-eight have been launched thus far; launch rate of 10 to 12 per year by 1970 is expected; Explorers have provided great quantities of scientific information on such phenomena as the Van Allen radiation region, the ionosphere, air density, meteoroids, magnetic fields, energetic particles, solar pressure and the effects of solar acitivity on the Earth environment; others will continue and complement these studies and explore new areas of interest

ICBM Alarm (Air Force)

MILITARY DESIGNATION: Redesignated Program 239A (formerly MIDAS)

TYPE: Early warning satellite

STATUS: Re-oriented back into development cycle due to sensor problems

PRIME CONTRACTOR: Lockheed

PERFORMANCE: Orbits of 300-3,000 mi.; polar; detects and warns of enemy ballistic missile launches; has had difficulty discriminating launches from other stimulation but some successes were reported in 1963

CONFIGURATION: No details available; program now consists of piggyback payloads

INSTRUMENTATION: Infrared radiation sensors by Aerojet-General

BOOSTER: Can be carried piggyback on various AF boosters

REMARKS: Was open program until secrecy order of March, 1961; orbital system concept changed from one of precise orbits to one of random orbits; a number of in-space detections have been made of both liquid and solid-fueled ICBM launches

Interplanetary Explorer (IMP) (NASA)

TYPE: Unmanned scientific satellites

MISSION: 135-lb. satellite to measure magnetic fields, cosmic rays and solar winds between the Earth and Moon; last 3 spacecraft will weigh 181 lbs.

STATUS: R&D

PRIME CONTRACTOR: Goddard Space Flight Center

POWER UNIT: Solar cells

BOOSTER: Thrust-Augmented Delta (TAD)

REMARKS: First IMP, Explorer XVIII, launched Nov. 26, 1963, pioneered in mapping the boundary of the Earth's magnetosphere; the orbit is highly elliptical; IMP B, launched Oct. 4, 1964, was successful but achieved a lower-than-planned orbit; IMP C launched on May 29, 1965, is in orbit; four more satellites planned, with two to be placed in lunar orbit

Nuclear Detection Satellite (ARPA)

TYPE: Detection-satellite system for nuclear explosions in space

STATUS: Development

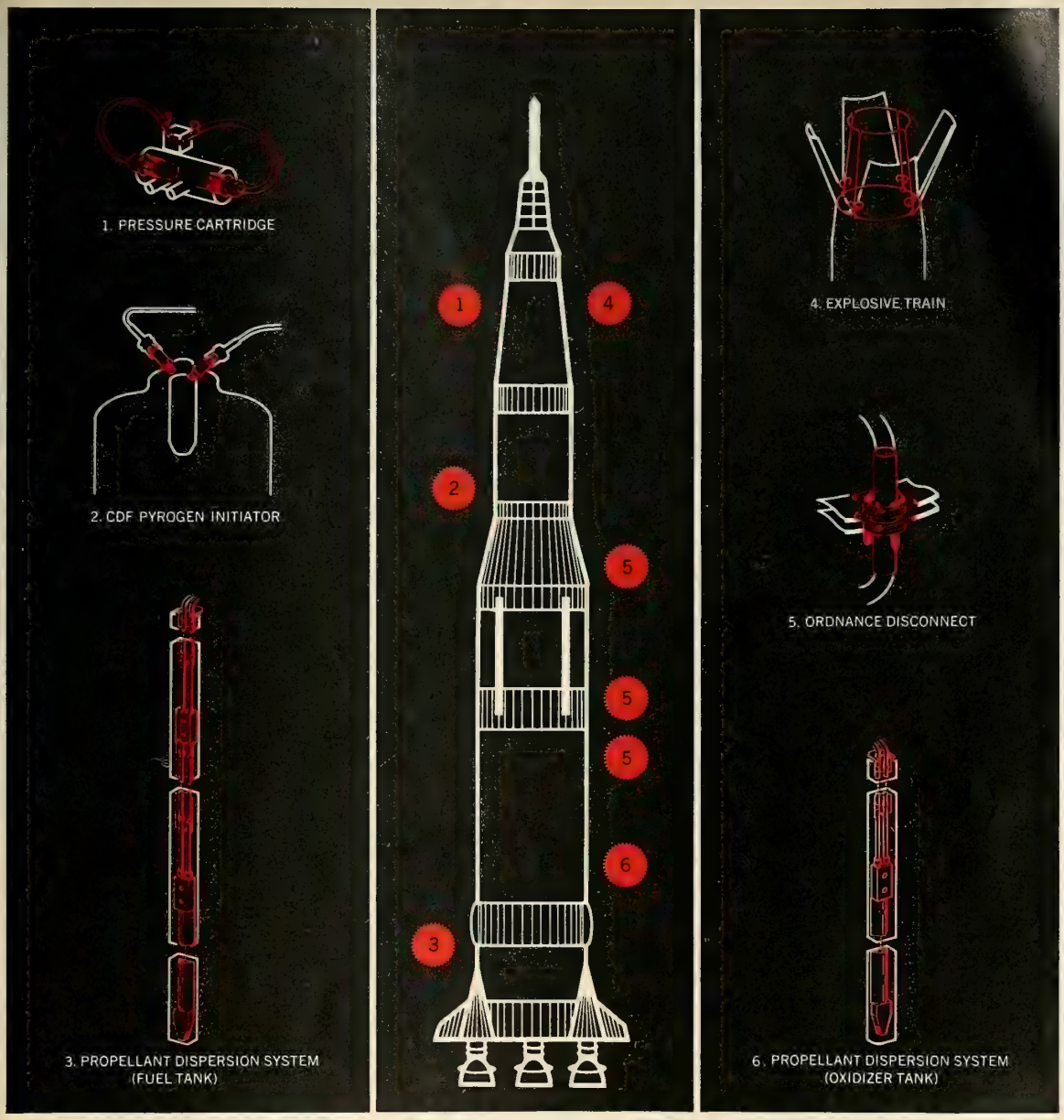
PRIME CONTRACTOR: TRW Systems Group; sensors, Los Alamos Scientific Laboratory and Aerospace Corp.

PERFORMANCE: Operational system would consist of three satellites in one orbital plane with three more in a plane 90 degrees from the first; orbital altitude 60,000 n. mi.; can detect x-rays from a one-megaton nuclear explosion at a distance of 3×10^5 km; also has other detection equipment for gamma ray detection and complex memory logic

FRAME: 20-sided satellite for maximum coverage; weight, 485 lbs.; maximum in dimension, 40 in.

BOOSTER: Atlas-Agena B

REMARKS: Initial pair of satellites were launched Oct. 17, 1963, in tandem and placed in virtually identical near-circular orbits; final positions were such that a constant separation of 100,000 mi. is maintained; 4 additional pairs of satellites were modified so as not to duplicate first launch data and second pair of nuclear test detection satellites was launched July 17, 1964; third pair launched July 20, 1965



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Optical Technology Satellite (NASA)

TYPE: Unmanned satellite

MISSION: Scientific satellite to provide a test bed for engineering research on space optics

STATUS: Study

CONTRACTORS: Selection of two firms to perform feasibility and design studies is imminent

BOOSTER: Saturn class

REMARKS: First flight to be made in 1969; hardware funding expected in the FY '67 budget

Orbiting Geophysical Observatory (NASA)

TYPE: Unmanned scientific satellite

MISSION: 1,000-lb. satellite with instruments for geophysical measurements; polar and eccentric orbits planned

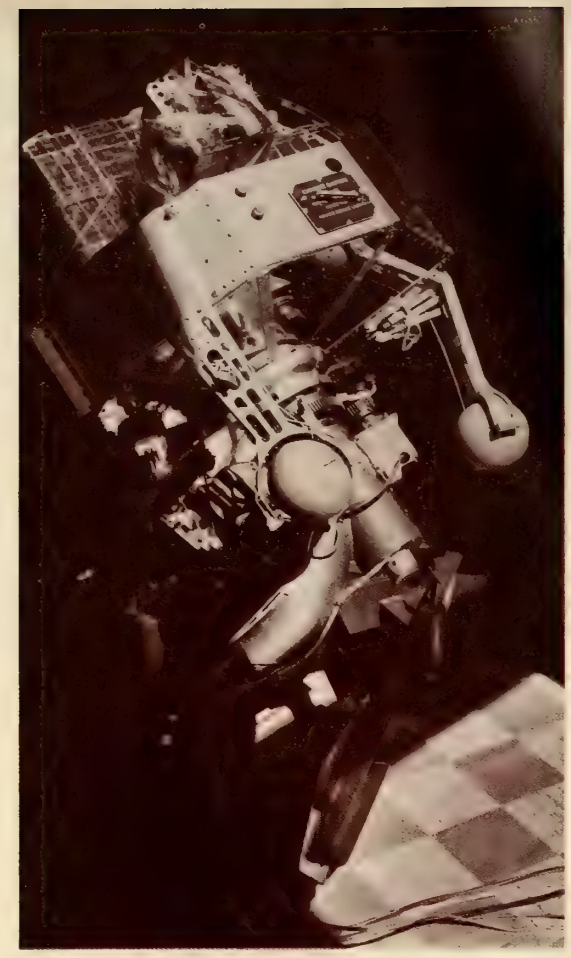
STATUS: R&D

PRIME CONTRACTOR: TRW Systems Group

PERFORMANCE: Capable of accommodating as many as 50 experiments

BOOSTER: Atlas-Agena and Thrust-Augmented Thor

REMARKS: First launch on Sept. 4, 1964, partially successful; 16 of 20 experiments working; five other launches planned, with the next flight scheduled for the second half of 1965



OSO

Orbiting Astronomical Observatory (NASA)

TYPE: Unmanned scientific satellite

MISSION: 3,600-lb. orbiting satellite to study astronomical phenomena from above the atmosphere

STATUS: R&D

PRIME CONTRACTOR: Grumman; Westinghouse, ground station

GUIDANCE: GE, stabilization and control; IBM, computer; Kollsman, star trackers; Hughes & AVCO, communications equipment

INSTRUMENTATION: Six star-tracker telescopes comprise a stellar frame of reference for precision pointing of experiments by ground command

BOOSTER: Atlas-Agena D

REMARKS: Three approved; first flight scheduled for late 1965 will study stellar photometry and spectra and will attempt a detailed map of the sky in ultraviolet light; second will carry a 36-in. telescope to photograph spectrum of selected celestial bodies; OAO will be a standardized space observatory

Orbiting Solar Observatory (NASA)

TYPE: Unmanned scientific satellite

MISSION: 540-lb. orbiting satellite to study electromagetic radiations from the Sun

STATUS: R&D

PRIME CONTRACTOR: Ball Brothers

BOOSTER: Delta

REMARKS: First flight Mar. 7, 1962, successful; OSO-2 launched Feb. 3, 1965, successful; six more flights scheduled; OSO-C, scheduled later this year, to carry 250 lbs. of experiments

Advanced Orbiting Solar Observatory (NASA)

TYPE: Unmanned scientific satellite

MISSION: 1,250-lb. satellite to observe a wide range of the solar electro-magnetic spectrum with greatly increased pointing accuracy, control flexibility, data-handling capacity and instrumentation

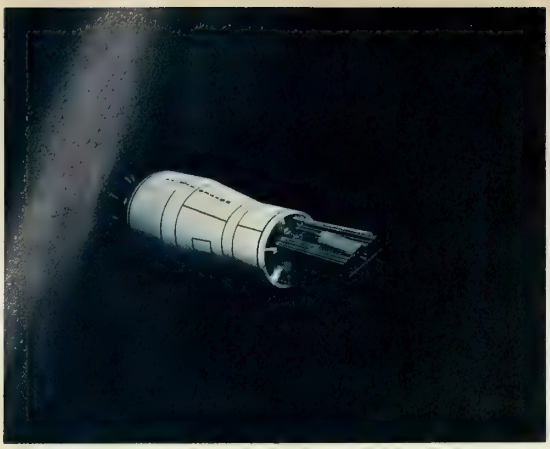
STATUS: R&D

PRIME CONTRACTOR: Republic

BOOSTER: Thrust-Augmented Thor-Agena

REMARKS: First hardware funding provided in the FY '66 budget; two spacecraft to be launched in 1969 and two in 1970

AOSO



Pegasus (NASA)

TYPE: Unmanned scientific satellite

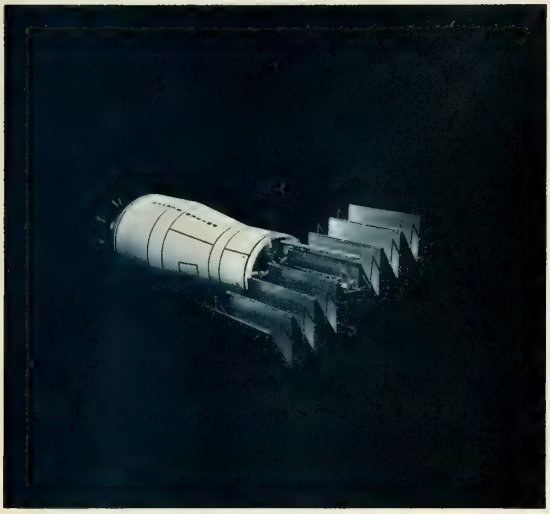
MISSION: 3,200-lb. satellite to measure meteoroid density in Earth orbit, employing two 50 x 15-ft. extendable detector wings

STATUS: R&D

PRIME CONTRACTOR: Fairchild Hiller Corp.

BOOSTER: Saturn I

REMARKS: Pegasus A, on Feb. 16, 1965, Pegasus B on May 25, 1965, launched successfully; Pegasus C, scheduled for launch on July 30, will carry detachable panels which may someday be removed by orbiting astronauts; cislunar satellite being considered by NASA



Radio Astronomy Observatory (NASA)

TYPE: Unmanned scientific satellite

MISSION: 270-lb. satellite which will have four 750-ft. extendable antennas to pinpoint radio emissions in space; launched at an inclination of 50 degrees with a circular 1,240-statute-mi. orbit

STATUS: R&D

CONTRACTOR: Goddard Space Flight Center, prime for first two spacecraft; industry to build four

BOOSTER: Thrust-Augmented Delta

REMARKS: First hardware funding in FY '65; first launch scheduled for 1967

Relay (NASA)

TYPE: Low-altitude active communication satellite

MISSION: 172-lb. satellite to receive and transmit radio and TV signals in an 800 to 4,600-mi orbit

STATUS: Operational

PRIME CONTRACTOR: RCA

INSTRUMENTATION: Duplicate systems for receiving and re-transmitting wideband TV, telephone and data signals; can handle a television transmission or 12 two-way voice channels; radiation monitoring and radiation damage detectors

POWER UNIT: Solar cells and batteries

REMARKS: Relay I in orbit Dec. 13, 1962; initial malfunction first apparent on fourth orbit corrected during December; successful use of satellite for experiments and demonstrations from Jan. 5, 1963, to present involving ground stations in U.S., Britain, France, Brazil, Italy, Germany, Japan and Spain; Relay II launched Jan. 21, 1964, operating successfully; no more launches scheduled

PEGASUS

SAMOS (Air Force)

MILITARY DESIGNATION: Redesignated Program 720A

TYPE: Reconnaissance satellite

STATUS: Operational

PRIME CONTRACTOR: Lockheed; sensors, Eastman Kodak; re-entry capsules, GE; recovery system, Avco & Northrop

CONFIGURATION: Length, 22 ft.; diameter, 5 ft.; weight, 4,100 lbs. with E-5 capsule, 3,000 lbs. with E-6 capsule; weights do not include entire Agena stage

PERFORMANCE: Polar orbit of 100-300 n. mi.; solar cell paddles extend operating time

INSTRUMENTATION: Photo intelligence equipment by Eastman Kodak

BOOSTER: Atlas-Agena or Thrust-Augmented Thor

REMARKS: System has highest national priority for recon efforts; apparently consists of one launch a month; photo equipment aboard has 20-day lifetime; processed film scanned by TV for immediately useful data, then recovered from orbit for detailed analysis after useful life ends; electronic eavesdropping version, known as Ferret, picks up communications and carries out electronic intelligence; system credited with giving evidence that "missile gap" was in our favor; major problem now appears to be a surfeit of useless data; a successor system, capable of changing orbital plane and altitude on command, is apparently being developed; this newer reconnaissance satellite would have up to six recoverable data capsules or cassettes with lifting-body characteristics, permitting data recovery without returning entire satellite to earth; could be launched by the Titan III-X booster now under development

Satellite Inspector (SAINT) (Air Force)

TYPE: Co-orbital satellite inspection system, Program 706

STATUS: Preliminary design

PRIME CONTRACTOR: None

PERFORMANCE: Original program was to have been able to detect and rendezvous to within 50 ft. of another spacecraft or satellite, changing altitude and orbital plane accordingly; however, work on this unmanned vehicle has been suspended

PAYLOAD: Expected to incorporate TV, optical, infrared radar and radiation sensors

REMARKS: Emphasis is on DOD experiments on Gemini, which may lead to a manned vehicle to perform this mission; ground-based systems are also being emphasized

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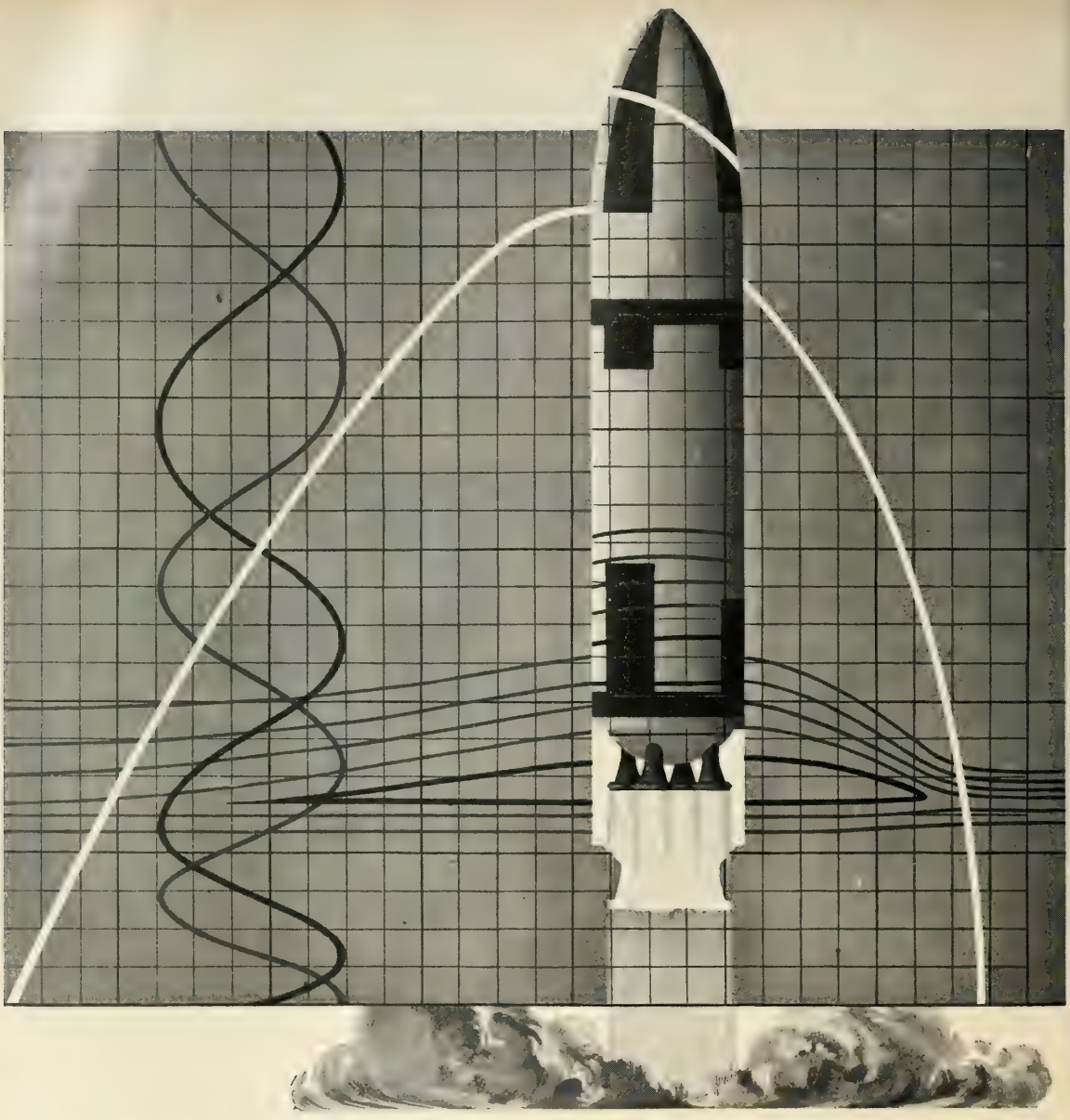

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TYPE: Geodetic satellite

STATUS: Operational

MISSION: To provide intercontinental datum ties

PRIME CONTRACTOR: Cubic Corporation

CONFIGURATION: Type I, spherical, diameter 20 in., weight 40 lbs.; Type II, rectilinear, measuring 9 x 11 x 14 in., weight 40 lbs.

BOOSTER: Can be carried piggyback on a variety of boosters

TRANSPONDER CONTRACTOR: Cubic Corp.

TRANSPONDER FREQUENCIES: 449 mc for geodetic measurements and 224.5 mc for refraction studies

REMARKS: Four satellites now in orbit, two of which are operating with optimum efficiency; all launches so far have been as piggy-back packages aboard secret Air Force launches from Vandenberg AFB; project sponsored by Army Engineer Corps

Synchronous Meteorological Satellite (NASA)

TYPE: Meteorological satellite

MISSION: To provide continuous monitoring of short-lived storms and cloud cover and of the whole disc of the Earth

STATUS: Study

PRIME CONTRACTOR: None; study contracts, Republic, RCA, Hughes

PERFORMANCE: 22,300-mi. orbit permits remaining over one point on Earth's surface

INSTRUMENTATION: TV cameras that view the entire Earth and/or selected areas will be used along with suitable radiometers

BOOSTER: Atlas-Agena or -Centaur

POWER UNITS: Undetermined

REMARKS: No funding expected until FY '67 at earliest; synchronous experiments scheduled to be flown on Applications Technologoy Satellite

Syncom (NASA)

TYPE: High-altitude active communications satellite

MISSION: Receive and transmit signals by way of 63-lb. satellite in a 22,300-mi. orbit

STATUS: Operational

PRIME CONTRACTOR: Hughes

INSTRUMENTATION: Communications, antenna, solar sensor, traveling wave tube, nickel cadmium batteries

POWER UNITS: Solar cells

BOOSTER: Delta

REMARKS: First launch into synchronous orbit on Feb. 14, 1963, but electrical failure on day of launch kept satellite from operating; second launch July 26, 1963, was successful; third successful on Aug. 19, 1964; satellite positioned in stationary orbit over the Pacific relayed 1964 Olympic Games from Japan to U.S.; no more launches planned; DOD has taken over satellites for operational use

TRS (Tetrahedral Research Satellite) (Air Force)

TYPE: Scientific satellite

MISSION: To measure effect of radiation on solar cells in space

STATUS: Operational

PRIME CONTRACTOR: TRW Systems Group

CONFIGURATION: Four-sided, weighing only 3 lbs. and measuring 4 in. on a side

REMARKS: Launched piggyback on a DOD payload Oct. 17, 1963; billed as world's smallest satellite; six launched to date

Tiros (NASA)

TYPE: Meteorological satellite

MISSION: 285-300-lb. meteorological satellite, TV pictures of cloud cover; transmits on ground command

STATUS: R&D

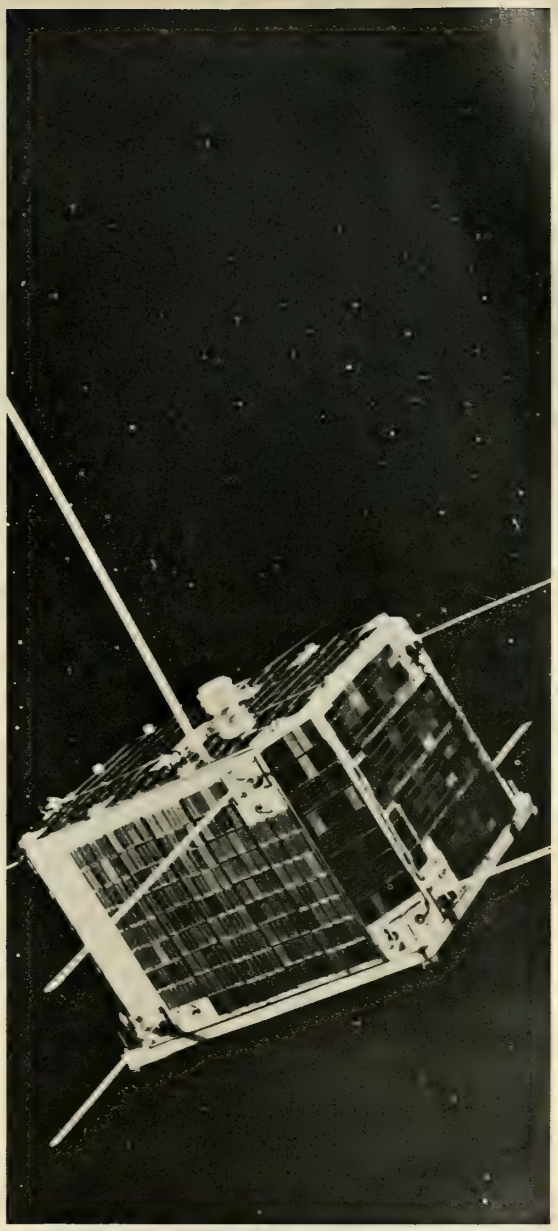
PRIME CONTRACTOR: RCA

INSTRUMENTATION: Scanning and non-scanning radiation sensors; narrow-, medium- and wide-angle cameras

POWER UNITS: Solar cells and nickel-cadmium storage batteries

BOOSTER: Delta

REMARKS: First launch April, 1960; second, Nov. 23, 1960; third, July 12, 1961; fourth, Feb. 8, 1962; fifth, June 19, 1962; sixth, Sept. 18, 1962; seventh, June 19, 1963; Tiros VIII launched Dec. 21, 1963, carried first automatic picture transmission system; can transmit to ground stations anywhere in world; all flights successful; Tiros IX, successfully launched on Jan. 22, 1965, is the first cartwheel configuration; Tiros X launched successfully on July 2, 1965; four more will be launched as part of the Weather Bureau's Operational System



SECOR

TIROS

ARIEL II

Transit (Navy)

TYPE: Navigation satellite

MISSION: Provide highly accurate position data to ships and aircraft on all-weather basis

STATUS: Operational

DEPLOYMENT: Four satellites in random, near-circular orbits at 600-n. mi. altitude

PRIME CONTRACTOR: Johns Hopkins Applied Physics Lab, R&D; Naval Avionics Facility, Indianapolis, production for Bureau of Naval Weapons

BOOSTER: Thor-Ablestar

FRAME: Flat-topped drum shape, 43 in. diameter, 31 in. high, weighs over 100 lbs. in final model; type now operational has four extendable vanes or wings to carry solar cells for power generation; uses gravity-gradient stabilization

INSTRUMENTATION: Electronic clock-memory system, magnetic stabilization system, four transmitters, solar cells and nickel-cadmium batteries

AUXILIARY POWER: Nuclear generator in one version by Martin

REMARKS: Expected to greatly reduce position errors for Polaris-firing submarines, to 0.1 mile; was first satellite to use a nuclear power generator; NASA will evaluate for a civilian navigation system; declared operational July, 1964

Ariel III (United Kingdom/NASA)

TYPE: Unmanned scientific satellite

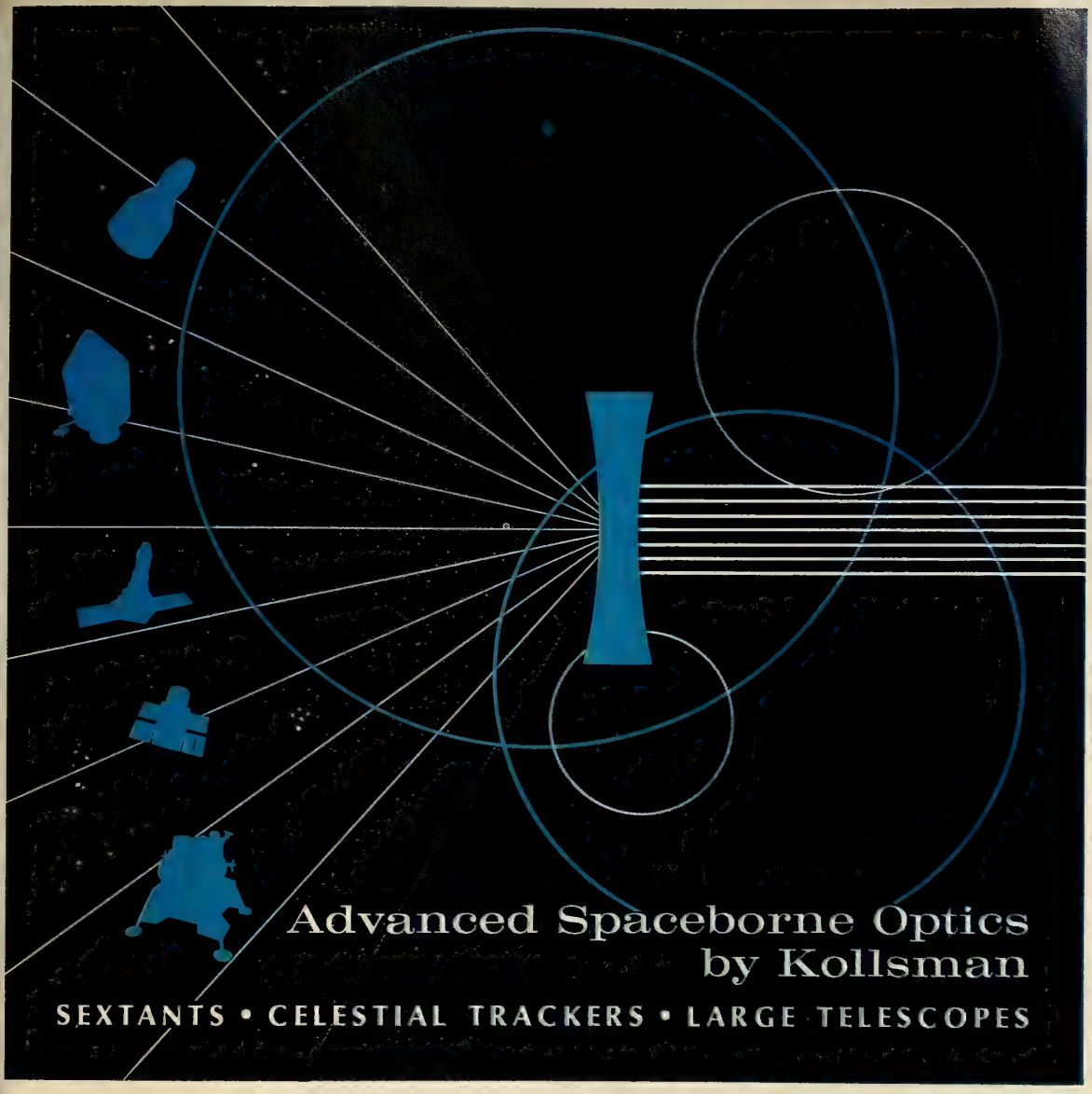
MISSION: Approximately 150-lb. satellite to measure large-scale noise sources in the galaxy and the intensity of VLF radiation

STATUS: R&D

CONTRACTOR: Royal Aircraft Establishment

BOOSTER: Scout

REMARKS: Ariel I and Ariel II were built and launched by NASA successfully on April 26, 1962, and March 27, 1964, respectively; Ariel III will be built by the British but launched by NASA from Wallops Island in late 1966; orbit will be near-circular with an altitude of 450 kilometers



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Agena D (Air Force)

TYPE: Upper stage

MISSION: Used as upper stage wth Thor and Atlas boosters for many programs

STATUS: Operational

PRIME CONTRACTOR: Lockheed

CONFIGURATION: Length variable with payload requirements; 5-ft. diameter; dead weight of 1,700 lbs.; sometimes equipped with solar cell paddles extending from base on scissors-arms; some models have afterskirt covered with solar cells; latter two configurations used with SAMOS and MIDAS

GUIDANCE: All-inertial by Honeywell

PROPULSION SYSTEM: Liquid-propellant rocket originally developed by Bell Aerosystems for B-58 bomber pod; propellants, IRFNA/UDMH; thrust, 16,000 lbs.; restartable at least four times

PERFORMANCE: Depends on booster; with Thor, 1,600 lbs. in 100-n. mi. orbit; with Thrust-Augmented Thor, about 2,500 lbs. in 100-n. mi. orbit; with Atlas D, over 5,000 lbs. in 100-n. mi. orbit; 750 lbs. to escape velocity and 400 lbs. to Mars or Venus; use of Agena with TAT has resulted in cost savings for missions which do not require the full Atlas capability

REMARKS: Used with SAMOS, Discoverer, Ranger, Mariner, OAO, OGO, Topside Sounder, Nimbus, Echo, Gemini, and other programs; an extremely versatile spacecraft, it is often used for piggyback launches (such as the ham radio satellite, Oscar, and the radiation-data satellite, TRS-1); also will be used as target vehicle for rendezvous in Gemini program

Atlas-Agena D (Air Force)

TYPE: Space booster

STATUS: Operational

PRIME CONTRACTOR: General Dynamics/Convair (Atlas); Lockheed (Agena)

PERFORMANCE: Payload, 5,000+ lbs. in 345-mi. orbit, 750 lbs. to escape, 400 lbs. for planetary missions

FRAME: Length, 102 ft.; diameter (base), 10 ft.; launch weight, 275,000 lbs.

GUIDANCE: System contractor, TRW Systems Group, Agena B; Honeywell, inertial reference

PROPULSION SYSTEM: Booster, Rocketdyne (modified Atlas D); type, liquid; thrust, 360,000 lbs.; Agena B, Bell Aerospace; type, liquid; thrust, 15,000 lbs.; restart capability

REMARKS: Used in Ranger, Discoverer, MACS, Mariner Lunar Orbiter, OAO, SAMOS, SNAP-10 and other space programs

Centaur (NASA)

TYPE: Multi-purpose upper stage

MISSION: To launch Surveyor and Mariner spacecraft on lunar and interplanetary missions; will also be used as upper stage for a variety of future space missions

STATUS: R&D

PRIME CONTRACTOR: General Dynamics/Convair

CONFIGURATION: Two RL-10 engines developing 30,000 lbs. total thrust; vehicle is 30 ft. long and 10 ft. in diameter

GUIDANCE: Honeywell; type, all inertial

PROPULSION: RL-10 LOX-liquid hydrogen engine, Pratt & Whitney

PAYLOAD: With Atlas D booster, Centaur will place 8,500 lbs. in 300-mi. orbit, 2,300 lbs. to escape velocity and 1,300 lbs. on planetary flights

REMARKS: First flight, May, 1962, failed when liquid hydrogen tank shielding broke off 55 sec. after launch; second launch Nov. 27, 1963, was successful; the third, June 20, 1964, was partially successful, meeting all objectives except full-duration burn of the Centaur stage; fourth launch, Dec. 11, 1964, was successful, but a planned second burn of the engines failed; fifth launch, March 2, 1965, failed when the Atlas booster failed one second after liftoff; Centaur 6 scheduled for late July or early August, 1965; two more flights scheduled this year, including the first Surveyor flight

Delta (NASA)

TYPE: Launch vehicle for medium-weight payloads

MISSION: Launch vehicle for Tiros, Echo, Explorer, Telstar and other programs

STATUS: Operational

PRIME CONTRACTOR: Douglas

FRAME: Height, 90 ft.; max. dia., 8 ft.

CONFIGURATION: Three stages

GUIDANCE: Bell Telephone Laboratories

PROPULSION: Liquid-solid; first stage, modified Thor (LOX/RP) (SM-75), thrust 170,000 lbs., Douglas; second, AJ 10-118 (IRFNA/UDMH), thrust, 7,500 lbs., Aerojet-General; third, Altair II (solid), thrust, 5,700 lbs., Allegany Ballistics Laboratory; second-stage burning time being increased from 170 to 400 seconds

PAYLOAD: 800 lbs. in 1,000-mi. orbit; 100 lbs. to escape; use of new improved second stage with 400-sec. burning time increases the payload to 950 lbs. in a 300-mi. orbit, 150 lbs. to escape and 120 lbs. to Mars and Venus

REMARKS: Use of new second stage will become operational in the last half of 1965; Deltas are being used to launch Tiros, Explorer, Orbiting Solar Observatory and other satellites; six more launches planned with old second stage; all other flights will use new, improved second stage

Thrust-Augmented Delta (NASA)

TYPE: Space launch vehicle

STATUS: Development

PRIME CONTRACTOR: Douglas

PERFORMANCE: 1,200 lbs. in 300-mi. orbit, 210 lbs. to escape and 160 lbs. to Mars and Venus

CONFIGURATION: Delta launch vehicle with three strap-on solids 120 degrees apart around base

PROPULSION CONTRACTOR: Thiokol for solid motors

PROPULSION: Three XM-33 solid motors producing 55,000 lbs. thrust each

REMARKS: First flight successfully placed Syncom III into orbit; booster will be used to launch Interplanetary Explorers (IMP), Orbiting Geophysical Observatory (OGO), Nimbus, Biosatellite and others

Little Joe II (NASA)

TYPE: Small solid booster

MISSION: Launch Apollo spacecraft in mission-abort test flight of the launch escape system

STATUS: Operational

THRUST: Up to 735,000 lbs., but varying depending upon number of solid motors and stages used

PRIME CONTRACTOR: General Dynamics/Convair

REMARKS: Two successful flight tests completed Aug. 28, 1963, and May 13, 1964; six vehicles ordered; early flights used one 105,000-lb.-thrust Algol rocket and six 34,000-lb.-thrust Recruit rockets; vehicle is sized to take seven Algols for a total thrust of 735,000 lbs.; third launch successful Dec. 8, 1964; fourth launch May 19, 1965, partially successful; high spin rate of launch vehicle caused premature separation of the boilerplate Apollo spacecraft; one more launch scheduled for late 1965

ATLAS-AGENA D

SATURN I

Rover (NASA & AEC)

TYPE: Nuclear rocket program

MISSION: High-specific-impulse nuclear stages to lift heavy payloads on lunar and planetary flights

STATUS: R&D

PROPULSION: Los Alamos Scientific Laboratory, reactor research and technology; Aerojet-General and Westinghouse, NERVA engine

REMARKS: Program aimed at providing technology needed for development of nuclear rocket systems for advanced space missions; program currently limited to ground testing; first hot firing of Phoebus graphite core reactor successful on June 25, 1965; NRX-A4 NERVA reactor will be fired in late third quarter, 1965; Phoebus will be used to power NERVA II nuclear engine, which will probably be the first such engine to be flight tested; flight test funding may be included in the FY '67 budget

Saturn I (NASA)

TYPE: Two-stage space launch vehicle with 1.5-million-lb.-thrust booster

MISSION: Launch boilerplate Apollos and Pegasus satellites into Earth orbits

STATUS: Operational

PRIME CONTRACTOR: S-1 stage, Chrysler; S-IV stage, Douglas

FRAME: 21.6 ft. wide; 125 ft. high

CONFIGURATION: S-1 stage, eight H-1 engines developing 1.5 million lbs. thrust; S-IV stage, six RL-10-A3 engines with 90,000 lbs. thrust

PROPULSION: All liquid; H-1, LOX/RP, Rocketdyne; RL-10A-3, LOX/H_2, Pratt & Whitney

PAYLOAD: 22,000 lbs. in 100-n. mi. orbit

REMARKS: First launch (SA-1) Oct. 27, 1961; SA-2, April 25, 1962; SA-3, Nov. 16, 1962; SA-4, March 28, 1963; first launch with live second stage, SA-5, Jan. 29, 1964; SA-6, May 28, 1964; SA-7, Sept. 18, 1964; SA-9, Feb. 16, 1965; SA-8, May 25, 1965, all successful; SA-10, scheduled for July 30, 1965, will end program; SA-9 & SA-8 both orbited Pegasus satellites; same payload will be launched on SA-10

Saturn IB (NASA)

TYPE: Two-stage space vehicle with 1.6 million lbs. thrust in the booster

MISSION: Boost Apollo spacecraft (including lunar-landing vehicle) models on Earth-orbital flights; also may be used as a supply vehicle in future programs

STATUS: R&D

PRIME CONTRACTORS: S-IB stage, Chrysler; S-IVB stage, Douglas

FRAME: 21.6 ft. dia., 141 ft. high

CONFIGURATION: S-IB stage, eight H-1 engines, total thrust, 1.6 million lbs.; first-stage thrust now being increased to 1.6 million lbs.; S-IVB stage, one J-2 engine, 200,000 lbs. thrust

PROPULSION: All liquid; Rocketdyne H-1, LOX/RP; Rocketdyne J-2, LOX/H_2

PAYLOAD: 45,000 lbs. in 120-mi. Earth orbit

REMARKS: First flight in 1966; first manned flight in 1967; three-stage Saturn IB with Centaur third stage funded in FY '66; will be used to launch Voyager spacecraft

Saturn V (NASA)

TYPE: Three-stage space launch vehicle with 7.5-million-lb.-thrust booster stage

MISSION: Prime booster for the first manned lunar-landing mission using the lunar-orbit rendezvous method; under study as booster for space station

STATUS: R&D

PRIME CONTRACTOR: S-IC stage, Boeing; S-II stage, North American; S-IVB stage, Douglas

FRAME: 33 ft. diameter; 281 ft. high

CONFIGURATION: S-IC stage, five F-1 engines, total thrust 7.5 million lbs.; S-II stage, five J-2 engines, total thrust 1 million lbs.; S-IVB stage, one J-2 engine, total thrust 200,000 lbs.

PROPULSION: All liquid; F-1 liquid oxygen/kerosene engine, Rocketdyne; J-2 liquid hydrogen/liquid oxygen engine, Rocketdyne

PAYLOAD: 280,000 lbs. in 105-n. mi. Earth orbit; 95,000 lbs. escape

REMARKS: First flight scheduled for 1967; engines for 10 vehicles already under contract

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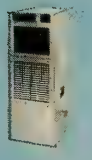

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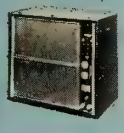

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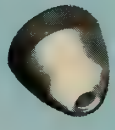

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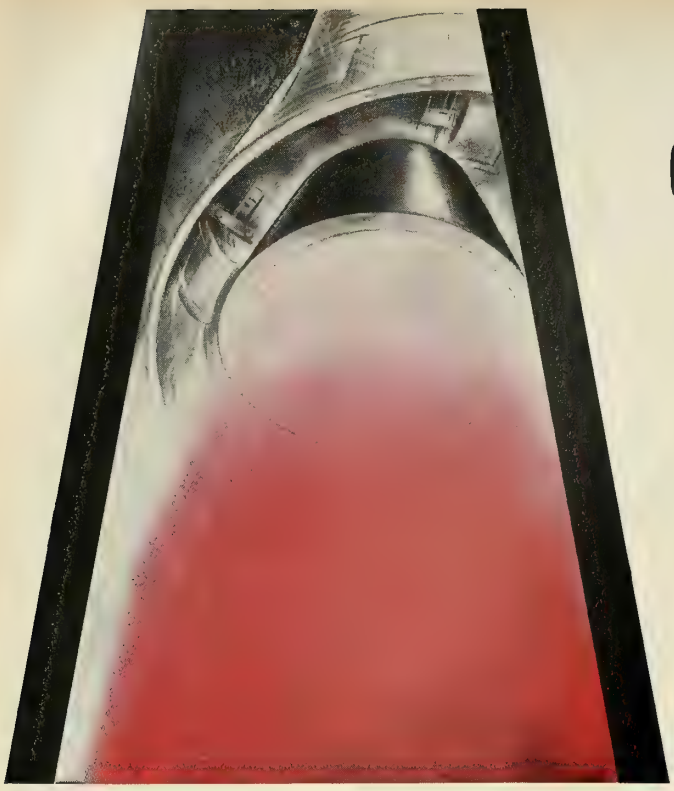

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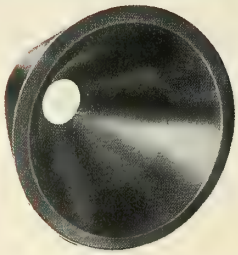

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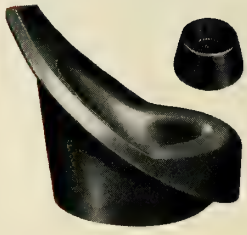

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Post-Saturn V Launch Vehicles (NASA)

TYPE: Multimillion-lb.-thrust space boosters

MISSION: Lunar exploration and manned planetary flights

STATUS: Under study

CONTRACTORS: Many study contracts awarded

PAYLOAD: Two-and-half to three times the 20-000-lb. payload of Saturn V

REMARKS: No hardware funding expected until FY '68; concepts studied include new high-pressure liquid engines, 156-in.- and 260-in.-dia. solid motors, nuclear-powered stages and various combinations of solid, liquid and nuclear propulsion

Scout (NASA)

TYPE: Launch vehicle for small payloads

MISSION: Booster for NASA and DOD scientific satellites, suborbital research missions and international satellites

STATUS: Operational

PRIME CONTRACTOR: LTV Aerospace Corp.; guidance, Honeywell

CONFIGURATION: 3.3 ft. maximum diameter, 72 ft. high

GUIDANCE: Honeywell; type, inertial reference

PROPULSION SYSTEM: All solid; first stage, Algol, Aerojet-General; second, Castor, Hercules; third, Antares II, Allegany Ballistics Lab; fourth, Altair II, Allegany Ballistics Lab

PAYLOAD: More than 240 lbs. in 300-mi. orbit; 80 lbs. to escape

REMARKS: Operational; used by NASA to launch small payloads such as Explorers; 23 more on order; updated Scout scheduled for launch on July 28; can put a 320-lb. payload into a 300-n. mi. orbit; uses a new fourth stage, designated FW-4S, developed by United Technology Center

Thor-Ablestar (Air Force)

TYPE: Space launch vehicle

STATUS: Operational

PRIME CONTRACTOR: Douglas and Space-General, associate contractors

PERFORMANCE: 900 lbs. in 100-n. mi. orbit

CONFIGURATION: Booster length, 55.9 ft., diameter, 8 ft., vehicle launch weight, 118,200 lbs., height 79 ft.; Thor (DSV-6) first stage; Ablestar second stage

GUIDANCE CONTRACTOR: Bell Telephone Labs

GUIDANCE: Radio command for both stages

PROPULSION CONTRACTOR: Rocketdyne, first stage; Aerojet-General, second

PROPULSION: RP/LOX first-stage producing 170,000 lbs. thrust; vernier engines on booster provide 2,000 lbs. thrust additional; UDMH/IRFNA second stage producing 7,900 lbs. thrust

REMARKS: Restart capability; used in Transit and other military programs

Thor-Agena D (Air Force and NASA)

TYPE: Space launch vehicle

STATUS: Operational

PRIME CONTRACTOR: None

PERFORMANCE: Payload, 1,600 lbs. in 300-mi. orbit

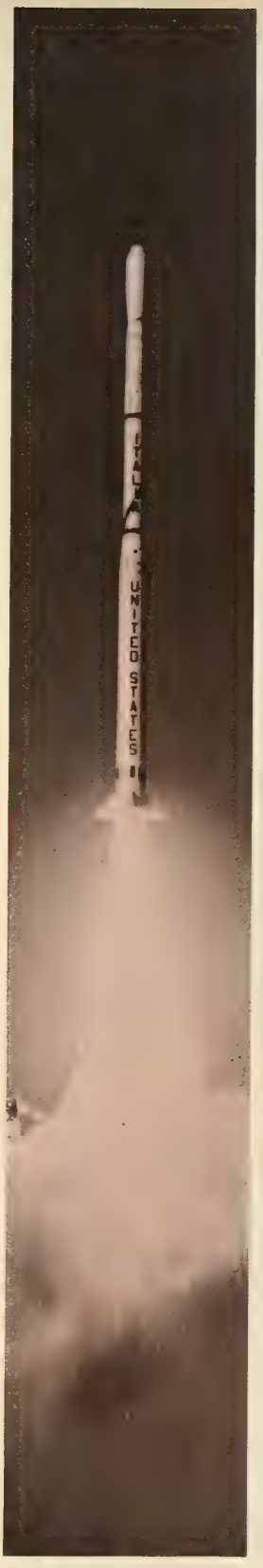
FRAME: Manufacturers—Douglas, Thor; Lockheed, Agena D; length overall 76 ft. (less spacecraft); diamter, 8 ft.; launch weight about 123,000 lbs.

PROPULSION: All-liquid, Rocketdyne, 172,000 lbs. thrust

GUIDANCE: Thor, Bell Telephone Labs; Agena D, Honeywell; type: Thor, radio; Agena, all-inertial

STAGES: 1, modified Thor IRBM, Douglas; Rocketdyne engine; 2, Agena, Engine-Bell XLR-81, Bell Aerospace; Agena vehicle, Lockheed

REMARKS: Used in Air Force space program; NASA has used in Telstar, Topside Sounder satellite and other programs; eleven NASA launches scheduled



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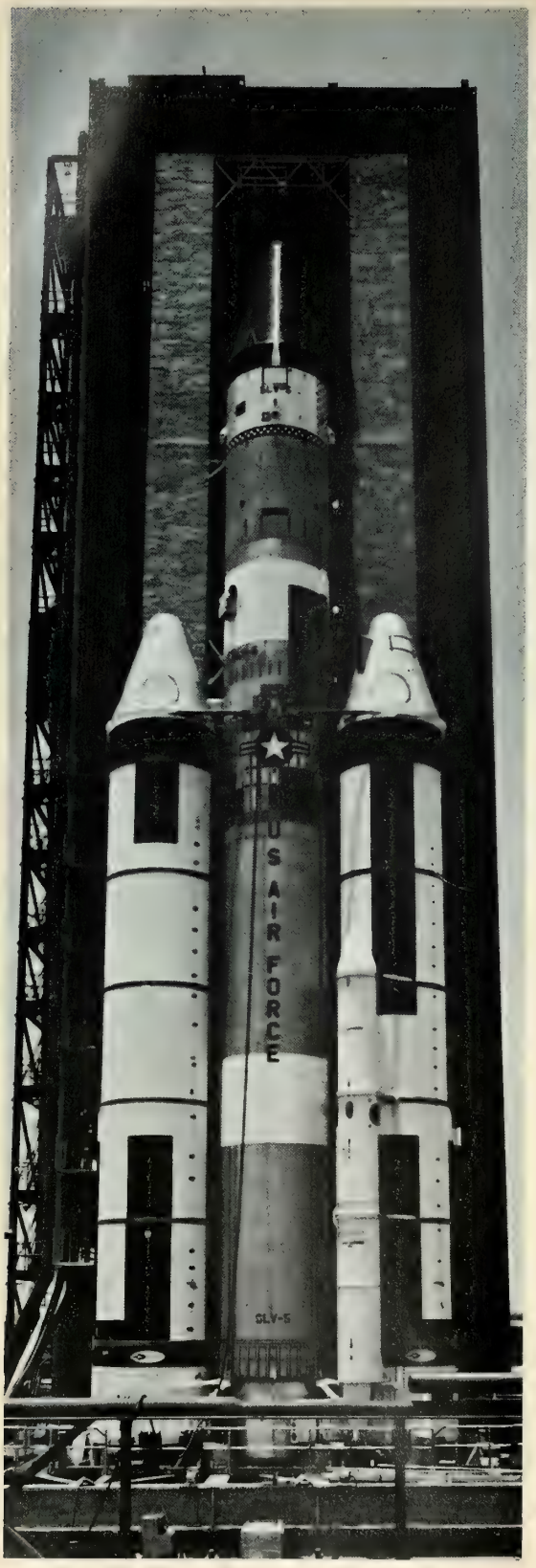

TITAN III-C

Thrust-Augmented Thor (TAT) (Air Force/NASA)

TYPE: Space launch vehicle

STATUS: Operational

PRIME CONTRACTOR: None

PERFORMANCE: 2,500 lbs. in 100-n. mi. orbit

FRAME: Three strap-on solids located 120 degrees apart at base of Thor; remaining stages same as Thor-Agena

PROPULSION: Thor, liquid, 172,000 lbs. of thrust; each strap-on has 55,000 lbs.

PROPULSION CONTRACTOR: Thor, Rocketdyne; solid, Thiokol

REMARKS: TAT, designated SLV IIC, is used by AF and NASA to orbit payloads too heavy for the Thor, but which would not utilize all the capacity of Atlas

Titan II (GLV) (NASA)

TYPE: Manned space booster

STATUS: Development

PRIME CONTRACTOR: Martin

CONFIGURATION: Essentially same as Titan II missile, with addition of redundant electrical power and flight control systems, a malfunction detection system to warn of abort situations and a radio command guidance system such as that used in Mercury

REMARKS: GT-1, an unmanned version of Gemini launch system, was successfully launched into orbit from Cape Kennedy April 8; GT-2, a ballistic flight, also unmanned, was successfully launched Jan. 19, 1965; GT-3, manned 3-orbit flight, was successful March 23, 1965; GT-4, manned 4-day mission, was successful June 3, 1965; next flight scheduled for mid-August; seven more to follow

Titan III (Air Force)

MILITARY DESIGNATION: Program 624A

TYPE: Standard space booster for quick-reaction military missions

STATUS: Development

CONTRACTORS: Martin, systems integration; UTC, large solid rockets; Martin, Titan II core vehicle; Aerojet-General, liquid rocket propulsion; AC Spark Plug, guidance

PERFORMANCE: Capable of placing 5,000-25,000 lbs. in low Earth orbits or 2,100 lbs. in synchronous orbits, depending on configuration

PROPULSION: Core vehicle, two liquid rocket engines with 430,000 lbs. thrust total; one liquid rocket engine with 100,000 lbs. thrust, and two liquid rocket engines with 8,000 lbs. thrust each; strap-on motors of two solid rockets, each 120 in. dia. generating 2.4 million lbs. thrust total and weighing 500,000 lbs. each

CONFIGURATION: Titan III-A is core vehicle (modified Titan II) with third (Transtage) stage; Titan III-C is full vehicle, using both outboard solid rockets; configuration used depends on mission parameters; Titan III-X, a non-manrated version, being developed for satellite launches, other missions; uses first two Titan III-A stages minus manrating electronics and an Agena upper stage; Centaur also being considered as an upper stage possibility; first launch planned in mid-1966; initial planned Titan III-X buy is 24 vehicles

REMARKS: First flight of Titan III-A September, 1964; first Titan III-C flight June 18, 1965; 17 development flights planned—5 Titan III-A and 12 Titan III-C; only four Titan III-A test shots fired; fifth core vehicle may be equipped with strap-on solid motors and fired as a thirteenth Titan III-C test vehicle; booster for MOL and possibly MACS; all Titan III-C flights beyond the first will carry bona fide payloads, the eleventh and twelfth reserved for preliminary, unmanned MOL launches

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Agena

MANUFACTURER: Bell Aerosystems
MANUFACTURER'S NUMBER: XLP-81-BA-5, -7 and -9
PROPELLANTS: RFNA and UDMH
NOZZLE MATERIAL: Uncooled titanium
LENGTH: 7 ft.
WIDTH: 3 ft.
WEIGHT: 300 lbs.
START SYSTEM: Solid propellant
IGNITION: Hypergolic
PROPELLANT SUPPLY: Turbopump, single restart
AVERAGE THRUST: 16,000 lbs.
BURNING TIME: Tank capacity
STATUS: Operational—to be used with OGO, Nimbus and USAF Agena vehicles; also target vehicle for Gemini rendezvous with added multiple restart feature

Agena Secondary Propulsion

MANUFACTURER: Bell Aerosystems
PROPELLANT: Mixed oxides of nitrogen and UDMH
NOZZLE MATERIAL: Haynes 25 alloy and tantalum-tungsten
DESIGN: Twin modules, each having 16- and 200-lb. thrust, radiation-cooled rocket motors
IGNITION: Hypergolic
PROPELLANT SUPPLY: Gas pressurization
STATUS: Ready for Gemini target vehicle mission in which unit serves to re-orient propellants in multi-restart Agena rocket engine and to make vernier adjustments to target vehicle's velocity preparatory to docking

Apollo Command Module Reaction Control System Engines

MANUFACTURER: Rocketdyne
MANUFACTURER'S NUMBER: SE-8
PROPELLANTS: Nitrogentetroxide and monomethylhydrazine
COOLING: Ablative
THRUST: 93 lbs.
REMARKS: Two sets of six engines each; one set redundant—will be used to position Apollo Command Module during re-entry; first engines delivered in February, 1965

Apollo Service Module

MANUFACTURER: Aerojet-General
MANUFACTURER'S NUMBER: AG 10-137
PROPELLANTS: Aerozene-50, nitrogen tetroxide, storable
NOZZLE MATERIALS: Thin welded titanium and columbium
NOZZLE EXP. RATIO: 60:1, high altitude
LENGTH: 152.8 in.
WIDTH: 98.4 in.
IGNITION: Hypergolic
PROPELLANT SUPPLY: Pressure-fed
AVERAGE THRUST: 21,900 lbs.
STATUS: Under development; unit will provide propulsion for the Apollo Service module to and from the Moon, in and out of lunar orbit and into the correct Earth re-entry window

Atlas Booster

MANUFACTURER: Rocketdyne
MANUFACTURER'S NUMBER: MA-2, MA-3, MA-5 (booster-LR90 NA-5; sustainer, LR105 NAO)
PROPELLANTS: LOX, RP-1
NOZZLE MATERIAL: Nickel
NOZZLE CONFIG. & EXP. RATIO: Bell, regen. cooled, 8:1
LENGTH: About 8 ft.
WIDTH (MAXIMUM): (one engine) 60 in.
WEIGHT: (one engine): 1,418 lbs.
START SYSTEM: MA-2-LOX-kerosene gas generator; MA-3, solid propellant
IGNITION: MA-2, pyrotechnic; MA-3, pyrophoric
PROPELLANT SUPPLY: Turbopump—twin pumps operated by single turbine for each chamber
AVERAGE THRUST: MA-2, 370,000 lbs.; MA-3, 389,000 lbs.; MA-5, 388,200 lbs., at sea level; sustainer, 57,000 lbs.
BURNING TIME: 120 sec.
STATUS: Atlas-Agena; Atlas-Centaur; systems under experimental modification to handle FLOX/RP-1 mixture; MA-5 system used to power SLV-3; system includes two vernier engines at 1,000 lbs. thrust each

Centaur Reaction Control System

MANUFACTURER: Bell Aerosystems
PROPELLANT: Hydrogen peroxide
NOZZLE MATERIAL: Stainless steel
IGNITION: Nickel-strained catalyst bed
PROPELLANT SUPPLY: Cold-gas pressurization
STATUS: Flight operational

Delta Second Stage

MANUFACTURER: Aerojet-General
MANUFACTURER'S NUMBER: AJ 10-118
PROPELLANTS: IRFNA and UDMH
LENGTH: 190 in.
WIDTH: 32 in. (max.)
WEIGHT: 645 lbs.
IGNITION: Hypergolic
PROPELLANT SUPPLY: Pneumatically pressurized tanks
AVERAGE THRUST: 7,500 lbs.
BURNING TIME: Tank capacity
STATUS: Thor-Delta scientific satellite launch vehicle

F-1 Engine

MANUFACTURER: Rocketdyne
MANUFACTURER'S NUMBER: F-1
PROPELLANTS: RP-1, LOX
NOZZLE CONFIG. & EXP. RATIO: Mod. bell; greater than 12:1; regen. cooled
LENGTH: About 18 ft.
WIDTH: About 12 ft.
WEIGHT: About 20,000 lbs.
START SYSTEM: Solid propellant
IGNITION: Electric spark
PROPELLANT SUPPLY: Turbopump
AVERAGE THRUST: 1.5 million lbs.
SPECIFIC IMPULSE: About 260 sec. (sea level)
BURNING TIME: Tank capacity
STATUS: Production engines being delivered to NASA and slated for Saturn V in clusters of 5 engines in first stage

Gemini Orbital Attitude Maneuvering System

MANUFACTURER: Rocketdyne
MANUFACTURER's NUMBER: SE-7
PROPELLANTS: Storable liquids
NOZZLE MATERIAL: Ablative
START SYSTEM: Hypergolic
THRUST: 8 engines at 25 lbs.; 6 engines at 100 lbs.; 2 engines at 85 lbs.
BURNING TIME: From several milliseconds to several minutes
STATUS: In production; 16 used on each capsule; positioned in adaptor section and jettisoned prior to re-entry

Gemini Orbital Re-entry Control System

MANUFACTURER: Rocketdyne
MANUFACTURER'S NUMBER: SE-6
PROPELLANTS: Storable liquids
NOZZLE MATERIAL: Ablative
START SYSTEM: Hypergolic
THRUST: 25 lbs. each
BURNING TIME: From several milliseconds to several minutes
STATUS: In production; 16 used on each capsule; eight thrustors in each of two systems; position capsule for re-entry phase

H-1 Engine

MANUFACTURER: Rocketdyne
MANUFACTURER'S NUMBER: H-1
PROPELLANTS: LOX, kerosene
NOZZLE CONFIG. & EXP. RATIO: Bell; 8:1; regen. cooled
NOZZLE MATERIAL: Stainless steel
LENGTH: About 8 ft.
WIDTH: 50 in. (max.)
WEIGHT: About 1,400 lbs.
START SYSTEM: Solid propellant
IGNITION: Pyrophoric
PROPELLANT SUPPLY: Turbopump
MAXIMUM THRUST: 188,000 lbs. uprated to 200,000
SPECIFIC IMPULSE: 255 sec. (sea level)
BURNING TIME: Tank capacity
STATUS: Cluster of 8 designated for Saturn I and IB

J-2 Engine

MANUFACTURER: Rocketdyne

MANUFACTURER'S NUMBER: J-2

PROPELLANTS: LOX, liquid hydrogen

AVEAGE THRUST: 200,000 lbs.

BURNING TIME: Tank capacity

STATUS: Slated for Saturn IB and V; will be used in cluster of 5 in S-II second stage of Saturn V and single engine in S-IVB stage of Saturn IB and Saturn V

M-1 Engine

MANUFACTURER: Aerojet-General

PROPELLANTS: LOX, liquid hydrogen

NOZZLE: Upper stage DeLaval type, gas-cooled

START SYSTEM: gas generator

IGNITION: Electric spark

PROPELLANT SUPPLY: Dual turbopumps (one per propellant); fuel pump is a two-stage unit

THRUST: 1.5 million lbs.

STATUS: First static test June 20, 1964; program not funded in NASA FY '66 budget

RL-10 Engine

MANUFACTURER: Pratt & Whitney Aircraft

MANUFACTURER'S NUMBER: RL-10A-3-1, RL-10A-3-3

PROPELLANTS: LOX, liquid hydrogen

NOZZLE CONFIG. & EXP. RATIO: Modified bell; 40:1 (RL-10A-3-1); 57:1 (RL-10A-3-3)

IGNITION: Exciter-spark

PROPELLANT SUPPLY: Bootstrap hydrogen gas-driven turbopump

THRUST: 15,000 lbs.

SPECIFIC IMPULSE: 433 sec. (RL-10A-3-1 nominal, in vacuum, at mixture ratio of 5.0); 444 sec. (RL-10A-3-3 nominal, in vacuum, at mixture ratio of 5.0)

BURNING TIME: Tank capacity

STATUS: RL-10A-3-1 model operational for major space missions on Centaur and Saturn S-IV stage; RL-10A-3-3 model presently under development for advanced Centaur application on Atlas and Saturn IB boosters; qualification test scheduled for August, 1966; advanced configuration capable of operation in low-thrust mode on tank pressure without turbopump rotation with gaseous, mixed-phase, or liquid propellants prior to acceleration to rated thrust; engine has demonstrated throttled operation from 100% to 10% of rated thrust

NERVA Engine

TYPE: Nuclear rocket engine

MISSION: Development of experimental nuclear rocket propulsion system

STATUS: R&D

PRIME CONTRACTOR: Aerojet-General

PROPULSION SYSTEM: Aerojet, overall system responsibility and development of non-nuclear hardware; Westinghouse Astro-nuclear Laboratory, development of nuclear reactor for engine based upon basic work performed by Los Alamos Scientific Laboratory

REMARKS: Joint NASA-AEC program with current objective of providing technology for first generation nuclear rocket engine through ground system tests; NRX-A3 reactor has been operated at various power levels, including full power; one unit has been restarted and run three times

Lunar Excursion Module Ascent Engine

MANUFACTURER: Bell Aerosystems

PROPELLANTS: Nitrogen tetroxide, 50/50 blend of hydrazine and UDMH

NOZZLE MATERIAL: Ablative

IGNITION: Hypergolic

PROPELLANT SUPPLY: Pressure-fed engine with series-parallel redundant valving with a valve-out capability

AVERAGE THRUST: 3,500 lbs.

STATUS: Under test at Manned Spacecraft Center's White Sands Operation

Lunar Excursion Module

DEVELOPER: TRW Systems Group

MANUFACTURER'S NUMBER: MIRA 10500

PROPELLANT: Nitrogen tetroxide, Aerozene-50

NOZZLE CONFIG. & EXP. RATIO: Bell; 48:1

IGNITION: Hypergolic

PROPELLANT SUPPLY: Pressure-fed

THRUST: Throttleable from 10,500 lbs. to 1,050 lbs.

BURNING TIME: 730 sec.

REMARKS: First delivery in fall, 1965; engine has been undergoing tests for almost a year

Poodle Engine (ACE, Air Force)

TYPE: Direct-cycle radioisotope

DEVELOPER: TRW Systems Group

PROPELLANT: Liquid hydrogen

RADIOISOTOPE: Po-210

PROPELLANT SUPPLY: Pressure-fed

THRUST: 0.25 lb.

DURATION: 30-40 days (continuous)

SPECIFIC IMPULSE: 750-800 sec.

REMARKS: Pilot model tested successfully, February, 1965; flight model to weigh 30 lbs.; length 13-17 in.; diameter, 4 in.

Surveyor Vernier Engine

MANUFACTURER: Thiokol

MANUFACTURER'S NUMBER: TD-339

PROPELLANTS: Nitrogen Tetroxide (90%)-nitrous oxide (10%) and monometylhydrozine

NOZZLE CONFIG. & EXP. RATIO: Overturned bell; 86:1

IGNITION: Hypergolic

PROPELLANT SUPPLY: Pressure-fed

THRUST: Throttleable from 30 to 104 lbs.

STATUS: Development complete; engine currently in type-approval testing

REMARKS: Capable of multiple restart; thrust chamber is regeneratively cooled and incorporates silicon carbide throat insert and radiation-cooled molybdenum nozzle extension; three engines per spacecraft

Circle No. 3 on Subscriber Service Card

ANNOUNCING

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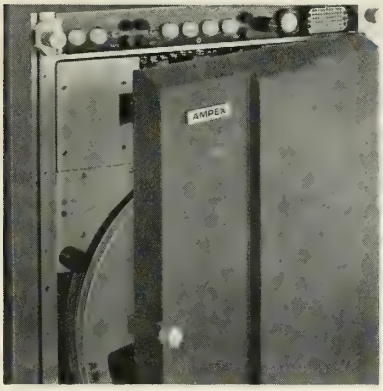
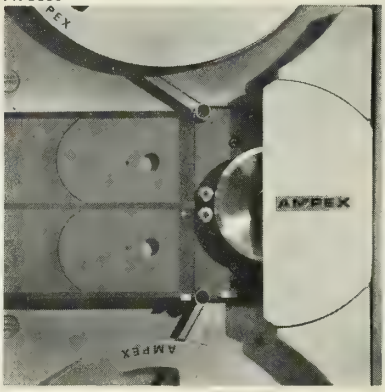
New Ampex 1600 Series

a matched family of 2 Mc recorders

AR-PR 1600



FR-1600



AR-PR 1600

Now: the first series of recorders designed to work together to improve overall systems performance. The 1600 lab-type, portable and airborne recorders feature full 2 Mc record/reproduce capability with near-absolute time base accuracy. This makes it possible to gather and re-create with great precision more usable data on *any recorder in the family.*

All 1600 recorders feature an important design innovation: a new, fast-response servo that gives a Time Base Error of ± 0.5 microsecond at 120 ips when reproduced on the lab recorder; a TBE of ± 2.0 microseconds when reproduced on the airborne and portable units. All offer direct and wideband FM recording. Envelope delay is uniform over the pass band.

FR-1600 Lab-Type Recorder

Unique vacuum drive system insures stable tape motion; reduces ITDE, TBE; minimizes flutter to less than 0.25%. Reels up to *16 inch* for 33% more playing time. Up to 14 channels of record and reproduce in one cabinet.

AR-1600 Airborne Recorder

Operates up to 70,000 feet. A rugged, compact 14 channel recorder *and* reproducer with coaxial *14 inch* reels. Flutter: less than 0.3%. Aircraft environment and power.

PR-1600 Portable Recorder

For field, van, shipboard and submarine use with performance same as AR-1600. 60 cps, 400 cps or 28 v.d.c. power.

AMPEX

Circle No. 4 on Subscriber Service Card

Also Ampex FR-1800

a new 1.5 Mc recorder

FR-1800

Now: a virtually fail-proof recorder—with 60% fewer parts than comparable recorders. The FR-1800 eliminates pinch rollers, linkages, belts, idlers and clutches. Result: new reliability, reduced maintenance and parts inventory. Chance for human error is virtually non-existent because of operating simplicity. The FR-1800 is fully compatible with 1.5 Mc, 300 Kc Direct—Wideband 400 Kc FM—Standard band 20 Kc FM, Frequency Shift Modulation and Pulse Duration Modulation. Because of its outstanding performance—high time base accuracy and low flutter—the FR-1800 reduces data collected on existing equipment and improves overall system performance. Heart of the new design: only one rotating part (exclusive of reels)—a fast-response, servo-controlled zero loop capstan that gives a TBE of less than ± 4.0 microseconds at 120 ips. Flutter: 0.25% from 0.2 cps to 10 Kc. Result: a reliable, economical recorder that could be the difference between gathering vital information or none at all. For complete details on the FR-1600 series and the FR-1800 recorder, write Ampex, Redwood City, California.

AMPEX

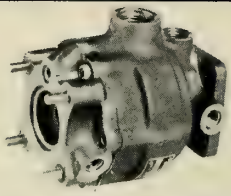
Circle No. 5 on Subscriber Service Card

Motorpumps, including integral gearboxes when required, for secondary power applications on aircraft and missiles combine reliability with light weight.

Auxiliary power units for primary and secondary fluid power systems are available in modular and completely integrated designs.

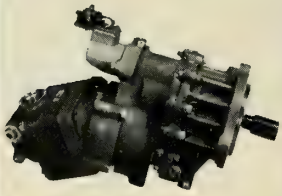
Hot gas motorpumps operate on bi-propellants and solid propellants for primary and secondary control power in missiles and space vehicles.

LOOKING FOR PROVED FLUID POWER AND CONTROL?

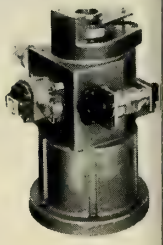


Vane-type fuel pumps offer high efficiency, high output and speed capability, significant weight reduction and meet severe contaminant tolerance specifications.

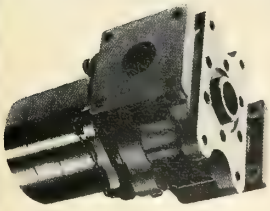
High temperature pumps like this are now operating on mineral-base fluid at 450°-550° fluid temperature and 3000 psi outlet pressure. Feasibility studies have been completed on pumps for future systems to 1200°F.



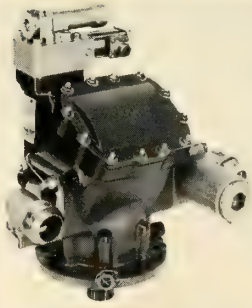
Compact, hydraulic starters perform repeated starting cycles and permit motoring of engine for extended periods. Also provide hydraulic pumping mode during flight.

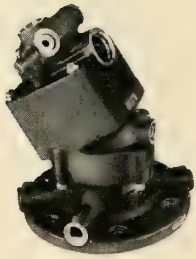


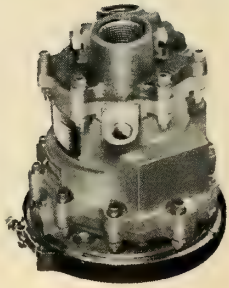
Servo-actuators, like t one for rapid tuning of r crowave transmitters, han a wide range of prec positioning tasks.



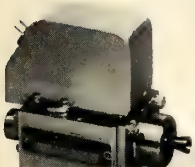
Single-stage, hot gas pressure regulating valve that controls combustion pressure of solid propellant gas generator is typical of complete line.







Yoke-type, fixed-angle and in-line variable displacement pumps combine millions of hours of inflight operation, let you choose the best pump for the application.



Pulse modulated rocket motor delivers to 6 pounds of thrust, requires 8 to 10 times less power input than previous state of the art.

For more details on these and many more applications, write for Bulletin A-5283A "Harnessing Fluids for Airborne Uses." Vickers Incorporated, P.O. Box 302, Troy, Michigan 48084.

VICKERS

DIVISION OF SPERRY RAND CORPORATION

Thor

MANUFACTURER: Rocketdyne
MANUFACTURER'S NUMBER: MB-3
PROPELLANTS: LOX and RP-1
COOLING: Regenerative
THRUST: 170,000 lbs.
LENGTH & WIDTH: 141 in. by 66.7 in.
REMARKS: MB-3 system also has two verniers used for roll control; system holds record for number of payloads launched

Titan I Booster

MANUFACTURER: Aerojet-General
MANUFACTURER's NUMBER: LR-87-AJ-3
PROPELLANTS: LOX, kerosene
NOZZLE MATERIAL: Nickel
NOZZLE CONFIG. & EXP. RATIO: Bell; 8:1; regen. cooled
LENGTH: About 10 ft.
WIDTH: About 9 ft. (max.)
WEIGHT: About 3,700 lbs.
START SYSTEM: Ground-supplied
IGNITION: Pyrotechnic
PROPELLANT SUPPLY: Turbopump
AVERAGE THRUST: 300,000 lbs.
BURNING TIME: 120 sec.

Titan II First Stage

MANUFACTURER: Aerojet-General
MANUFACTURER'S NUMBER: YLR-87-AJ-5
PROPELLANTS: Nitrogen tetroxide; Aerozene-50
NOZZLE CONFIG. & EXP. RATIO: Bell; regen. cooled; 8:1
START SYSTEM: Bootstrap
IGNITION: Hypergolic
PROPELLANT SUPPLY: Turbopump
AVERAGE THRUST: 430,000 lbs. (two barrel); 474,000 lbs. at altitude start in Titan III-C configuration
BURNING TIME: Tank capacity
REMARKS: (See Titan II in missile section)

TITAN II FIRST STAGE

Titan II Second Stage

MANUFACTURER: Aerojet-General

MANUFACTURER'S NUMBER: YLR-91-AJ-5

PROPELLANTS: Nitrogen tetroxide, Aerozene-50

NOZZLE CONFIG. & EXP. RATIO: Mod. bell; 45:1; regen. cooled

START SYSTEM: Bootstrap

IGNITION: Hypergolic

PROPELLANT SUPPLY: Turbopump

THRUST: 100,000 lbs., single-barrel

BURNING TIME: More than 3 minutes in Gemini use

REMARKS: Man-rated for Gemini launch applications

Titan III Transtage Attitude Control System

MANUFACTURER: Rocketdyne

MANUFACTURER'S NUMBER: SE-9 (covers system of eight small engines for attitude control and ullage)

PROPELLANTS: Nitrogen tetroxide-monomethylhydrazine

COOLING: Ablative

THRUST: 25 lbs. and 45 lbs.

REMARKS: System composed of positive propellant tanks, pressurizing system and eight engines; four engines develop 25 lbs. thrust and four reach 45 lbs. thrust

Titan III-C Staging Rockets

MANUFACTURER: Jnited Technology Center

PROPELLANT: PBAN with aluminum additives and ammonium perchorate oxidizer

NOZZLE MATERIAL: Composite structure with aluminum housing, asbestos phenolic exit cone and graphite throat

DIMENSIONS: 5 ft. long, 6 in. wide

THRUST: 4,500 lbs.

DEVELOPMENT STATUS: Flight tests under way

REMARKS: Each Titan III-C booster motor carries eight staging rockets for separation from the Titan III-C core after burnout

Titan III Engines

MANUFACTURER: Aerojet-General

REMARKS: Titan II engines used in modified form; principal changes are in upper-altitude capabilities for the YLR-87-AJ-5 and the incorporation of a malfunction detection system; both liquid stages man-rated; first stage re-designed to start either on ground or in space and engine efficiency increased to accommodate various payloads; second-stage operating time increased beyond Gemini range

Titan III-C Boosters

MANUFACTURER: United Technology Center

MANUFACTURER'S NUMBER: 1205

PROPELLANT: PBAN with aluminum additives and ammonium perchlorate oxidizer

NOZZLE MATERIAL: Steel with graphite cloth-phenolic and silica cloth-phenolic exit cone liner

DIMENSIONS: 92 ft. tall; 10 ft. dia.

WEIGHT: Approximately 500,000 lbs.

IGNITION: Small solid rockets

AVERAGE THRUST: More than 1,000,000 lbs.

BURN TIME: About 110 sec.

STATUS: In flight test

REMARKS: Each Titan III-C carries two 1205 motors; each motor consists of five center segments, two end closures, nozzle, nose cone, thrust termination and destruct system, and secondary liquid injection TVC; in addition to five-segment Titan III-C configuration, the 120-in.-dia. motors can be used in one- to seven-segment versions.

X-15 Rocket Engine

MANUFACTURER: Thiokol

MANUFACTURER'S NUMBER: TD-214

MILITARY DESIGNATION: YLR99-RM-1

PROPELLANTS: LOX/ammonia

NOZZLE CONFIG. & EXP. RATIO: Conical; 9.8:1

IGNITION: Two-stage igniter; first stage, spark ignition; second stage ignited by first-stage combustion

PROPELLANT SUPPLY: Two centrifugal pumps driven by two-stage impulse turbine

THRUST: Throttleable from 15,000 lbs. to 57,000 lbs. (vacuum)

WEIGHT (DRY): 910.0 lbs.

BURN TIME: Limited only by propellant supply; standard X-15; 88 sec. at maximum thrust; modfiied A-2, 146 sec. at max. thrust

STATUS: Operational in all X-15 vehicles

REMARKS: Engine fully man-rated; capable of 100 restarts

Titan III Transtage

MANUFACTURER: Aerojet-General

PROPELLANTS: Storables—nitrogen tetroxide, Aerozene-50

START SYSTEM: Gas pressurized system

IGNITION: Hypergolic

WEIGHT: 228 lbs. each

RESTARTS: Unlimited

AREA RATIO: 40:1

THRUST: 16,000 lbs. total—8,000 lbs. from each of the twin barrels

REMARKS: Capable of start/stop operation in zero-g environment; engine has ablative chambers and titanium exhaust skirt; engine is slated to provide orbital changes for Titan III payloads

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Identification: 1. Tape wound tactical missile nose cone. 2. Radomes. 3. Prop spinner fairing. 4. Molded gun turret enclosures. 5. Tape wound ablative shield. 6. Molded ablative nose cone section. 7. Miscellaneous molded hardware. 8. Sectioned thrust chamber.

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UNITED STATES: RESEARCH AND SOUNDING ROCKETS

Listed under system contractor: manufacturer's nomenclature, type, stages and thrust, launch weight and overall length, performance, remarks and using organizations.

AEROLAB DEVELOPMENT CO.

ARGO A-2 (PERCHERON) Boosted single-stage solid research rocket, Thiokol Castor TX-33 with two Thiokol Recruit TE-29's (122,000-lb. total thrust); weight, 10,000 lbs.; length, 21 ft.; 500-lb. payload to altitude of 200 n. mi.; first stage Shotput; NASA

ARGO A-3 Single-stage solid research rocket, Hercules M-6 Honest John (86,000-lb. thrust); weight, 5,910 lbs.; length, 21 ft.; 2,000-lb. payload to altitude of 10 n. mi.; used in Goodyear/USAF-ASD ballute tests; AF

ARGO B-1 Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Cajun TE-82 (9,600-lb. thrust); weight, 1,540 lbs.; length, 23 ft.; 50-lb. payload to altitude of 100 n. mi.; NASA, AF

ARGO B-7 Two-stage solid research rocket, 1st—Hercules M-6 Honest John (86,000-lb. thrust); 2nd—Hercules M-5 Nike (48,700-lb. thrust); weight, 5,900 lbs.; length, 31 ft.; 400-lb. payload to altitude of 40 n. mi.; used in Goodyear/USAF-ASD ballute tests; AF

ARGO B-8 Two-stage solid research rocket, 1st and 2nd—Hercules M-5 Nike (48,700-lb. thrust each); weight, 28,000 lbs.; length, 27 ft.; 400-lb. payload to altitude of 30 n. mi.; used in Goodyear/USAF-ASD ballute tests; AF

ARGO B-9 Two-stage solid research rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Yardbird TE-289 (17,100-lb. thrust); weight, 1,800 lbs.; length, 24 ft.; 100-lb. payload to altitude of 130 n. mi.; under development; AF

ARGO B-11 Boosted two-stage solid research rocket, 1st—Thiokol Castor TX-33 w/two Thiokol Recruit TE-29's (122,000-lb. total thrust), 2nd—Hercules X-259 (21,350-lb. thrust); weight, 13,200 lbs.; length, 34 ft.; 1,000-lb. payload to altitude of 450 n. mi; under development; NASA

ARGO B-13 Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Apache TE-307 (5,000-lb. thrust); weight, 1,600 lbs.; length, 27 ft.; 60-lb. payload to altitude of 135 n. mi.; operational; NASA

ARGO B-21 Boosted two-stage solid research rocket, 1st—Thiokol Castor TX-33 w/two Thiokol Recruit TE-29's (122,000-lb. total thrust), 2nd—Thiokol Subroc TX-261 (57,000-lb. thrust); weight, 13,000 lbs.; length, 42 ft.; 1,300-lb. payload to altitude of 250 n. mi.; under development (in-house)

ARGO B-23 Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—United Tech. Ctr. FW-3 (6,000-lb. thrust); weight, 2,160 lbs., length, 22 ft.; 100-lb. payload to altitude of 360 n. mi.; under development; Navy

ARGO C-21 Boosted three-stage solid sounding rocket, 1st—Thiokol Castor TX-33 w/two Thiokol Recruit TE-29's (122,000-lb. total thrust), 2nd—Hercules X-259 (21,350-lb. thrust), 3rd—United Tech. Ctr. FW-3 (6,000 lb. thrust); weight, 13,620 lbs.; length, 50 ft.; 250-lb. payload to altitude of 1,250 n. mi.; Mach 19; under development; AF

ARGO C-22 Three-stage solid sounding rocket, 1st—Hercules M-6 Honest John (86,000-lb. thrust), 2nd & 3rd—Hercules M-5 Nike (48,700-lb. thrust each); weight, 6,950 lbs.; length, 43.6 ft., 212-lb. payload to altitude of 120 n. mi.; Mach 6; uses swept-back stabilization fins; AF

ARGO C-23 Three-stage solid sounding or research rocket, 1st—Thiokol TX-33 with two Thiokol TX-77's (147,000-lb. total thrust), 2nd—Thiokol TX-261 (57,000-lb. thrust), 3rd—Thiokol TX-306 (11KS-13430); weight 14,300 lbs; length, 41.3 ft.; 150-lb. payload to altitude of 2,000 n. mi., Mach 21; in development for AF

ARGO D-4 (JAVELIN) Four-stage solid research rocket, 1st—Hercules M-6 Honest John (86,000-lb. thrust), 2nd & 3rd—Hercules M-5 Nike (48,700-lb. thrust each), 4th—Hercules X-248 (3,000-lb. thrust); weight 7,400 lbs.; length, 48.7 ft.; 100-lb. payload to altitude of 550 n. mi.; NASA, AF

ARGO D-8 (JOURNEYMAN A) Four-stage solid research rocket; 1st—Thiokol XM-20 w/two Thiokol 1.5KS-3500 Recruits (121,000-lb. total thrust), 2nd & 3rd—Lockheed Lance (47,000-lb. thrust each), 4th—Hercules X-248 (3,000-lb. thrust); weight 14,000 lbs.; length, 62.0 ft.; 135-lb. payload to altitude of 1,260 n. mi.; Mach 24; holds record for highest altitude (1,269 n. mi.) for recovered payload; NASA

ARGO E-5 (JASON) Five-stage solid sounding rocket, 1st—Hercules M-6 Honest John (86,000-lb. thrust), 2nd & 3rd—Hercules M-5 Nike (48,700-lb. thrust each), 4th—Thiokol TX-77 (46,000-lb. thrust), 5th—Thiokol T-55 (4,650-lb. thrust); weight 7,250 lbs.; length, 56.5 ft.; 50-lb. payload to altitude of 500 n. mi.; Mach 12.5; AF

TRAILBLAZER I Six-stage (incl. three downward-thrust packaged in reverse in 3rd stage) solid research rocket, 1st—Hercules M-6 Honest John (86,000-lb. thrust), 2nd—Hercules M-5 Nike (48,700-lb. thrust), 3rd—either Lockheed Lance (47,000-lb. thrust) or Thiokol TX-77 (46,000-lb. thrust), 4th—Thiokol T-40, 5th—Thiokol T-55 (4,650-lb. thrust), 6th—NASA/Langley 5-in. spherical motor; weight, 7,500 lbs.; length, 56 ft.; three stages up to altitude of 200 n. mi.; three stages down attain 24,000 fps (a "gun-fired" pellet fired downward has reached 35,000 fps); NASA

AMERICAN MACHINE AND FOUNDRY CO.

PURR KEE, ADVANCED Two-stage sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Hercules X-220 (6,400-lb. thrust); length, 6 ft.; in development for Navy

ATLANTIC RESEARCH CORP. (ARC)

ARCAS Single-stage solid sounding rocket, ARC 29KS-336; weight, 65 lbs.; length, 6.6-9.1 ft.; 12-lb. payload to altitude of 40 mi.; all services and NASA

ARCAS, BOOSTED Two-stage solid sounding rocket, 1st—ARC IKS-2200, 2nd—ARC Arcas 29KS-336; weight, 100 lbs.; length, 10.5 ft.; 12-lb. payload to altitude of 50 mi.; all services, NASA, Canada, Sweden

ARCHER Single-stage solid sounding rocket, ARC 35KS-1375; weight, 330 lbs.; length, 12.8 ft.; 40-lb. payload to altitude of 90 mi.; all services and NASA

ATHENA Two, three, or four-stage research rocket, 1st—Thiokol Castor TX-33 w/ two Thiokol Recruit TE-29's (122,000 lb. total thrust), 2nd—either Hercules X-259 (19,000-lb. thrust) or Thiokol TX-261 (57,000-lb. thrust) depending on trajectory requirements, 3rd—Aerojet 30KS-8000, 4th—Hercules BE-3; weight, 16,000 lbs.; length, 50 ft.; 50 to 300-lb. payload to altitude of 200-500-mi.; four-stage version will employ two stages going up, fin stabilized, and two stages down, with guidance in 3rd stage; pre-selected angle-of-attack control 0° ±5°; flight distance 417 n. mi.; re-entry velocities from 16,000 to 23,000 fps; for advanced re-entry research and plasma-sheath studies; AF, ARPA

HONEST JOHN-NIKE-NIKE Three-stage solid sounding rocket, 1st—Hercules M-6 Honest John (86,000-lb. thrust), 2nd and 3rd—Hercules M-5 Nike (48,700-lb. thrust); weight, 6,500 lbs.; length 47 ft.; 250-lb. payload to altitude of 135 mi.; Army, AF, NASA

HYDRA-IRIS Two-stage solid sounding rocket, 1st—three clustered Aerojet Sparrow 1.8-KS-7800's (22,400-lb. total thrust), 2nd—ARC 52KS-4375; weight, 1,350 lbs.; length 24 ft.; 100-lb. payload to altitude of 200 mi.; Navy

IRIS Single-stage solid sounding rocket, ARC 52KS-4375; weight, 1,350 lbs.; length 24 ft.; 100-lb. payload to altitude of 200 mi.; all services and NASA

METROC Single-stage solid sounding rocket, ARC 16KS-140; weight, 15 lbs.; length, 4.6 ft.; 2-lb. payload to altitude of 20 mi.; all services and NASA

METROC, BOOSTED Two-stage solid sounding rocket, 1st—ARC Metroc 16KS-140, 2nd—2.75 FFAR (Navy rocket, 720-lb. thrust); weight, 26 lbs.; length, 8.8 ft.; 2-lb. payload to altitude of 52 mi.; all services and NASA

NIKE-APACHE Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Apache TE-307 (5,900-lb. thrust); weight, 1,550 lbs.; length, 23 ft.; 50-lb. payload to altitude of 130 mi.; all services and NASA

NIKE-ARCHER Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—ARC Archer 35KS-1375; weight, 1,650 lbs.; length, 25 ft.; 40-lb. payload to altitude of 230 mi.; all services and NASA

NIKE-CAJUN Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Cajun TE-82 (9,600-lb. thrust); weight, 1,550 lbs.; length, 23 ft.; 50-lb. payload to altitude of 100 mi.; all services and NASA

SIDEWINDER-HV ARCAS Two-stage solid sounding rocket, 1st—Naval Propellant Plant Sidewinder 1A, 2nd—ARC high-velocity Arcas 29KS-336; weight; 168 lbs.; length, 13.8 ft.; 12-lb. payload to altitude of 81 mi.; all services

SPARROW-HV ARCAS Two-stage sounding rocket, 1st—Aerojet Sparrow I, 2nd—ARC high-velocity Arcas 29KS-336; weight, 206 lbs.; length, 13 ft.; 12-lb. payload to altitude of 100 mi.; all services

SWIK Two-stage solid research rocket, 1st—Thiokol Castor TX-33 (55,000-lb. thrust), 2nd—Hercules X-254 (14,100-lb. thrust); weight, 13,200 lbs.; length, 35 ft.; 300-lb. payload to altitude of 675 mi.; Army, AF

TRAILBLAZER II Four-stage solid research rocket, 1st—Thiokol Castor TX-33 with two Thiokol Recruit TE-29's (122,000-lb. total thrust), 2nd—Lockheed Lance (47,000-lb. thrust), 3rd—Hercules Altair X-248 (3,000-lb. thrust), 4th—ARC/NASA 15-in. spherical (5,000-lb. thrust); weight, 13,344 lbs.; length, 50 ft.; two stages up, two stages downward to achieve re-entry velocity of 22,000 fps; NASA, Army, AF

HERCULES POWDER CO.

DEACON (POGO-HI) Single-stage Hercules X-220 solid motor (6,100-lb. thrust); weight, 155 lbs.; length, 9.2 ft.; payload weight vs. altitude varies with each program; Army, Navy, NASA, ARPA

LANGLEY RESEARCH CENTER, NASA

METEOR SIMULATION VEHICLE (1) (Modified Trailblazer II); Six-stage solid research rocket; 1st—Thiokol Castor TX-33 w/two Thiokol Recruit TE-29's (122,000-lb. total thrust), 2nd—Lockheed Lance (47,000-lb. thrust), 3rd—Hercules Altair X-248 (3,000-lb. thrust), 4th—NASA Cygnus-15 (3,200-lb.-thrust, 15-in.-dia. spherical), 5th—NASA Cygnus-5 (550-lb.-thrust, 5-in.-dia. spherical), 6th—Army Ballistics Research Lab. shaped-charge accelerator and re-entry pellet; ARC spin-stabilized velocity package contains last four stages; 13,500 lbs., 51.5 ft.; two stages up to 300-km altitude, remaining stages packaged in reverse to achieve 20 km-sec. re-entry velocity, 15 deg. off vertical at 75-km altitude; NASA

METEOR SIMULATION VEHICLE (2) (Modified Nike-Cajun); Four-stage solid research rocket; 1st—Hercules Nike (53,000-lb.-thrust), 2nd—Thiokol Cajun TE-82 (8,600-lb.-thrust), 3rd—NASA Cygnus-5 (550-lb.-thrust, 5-in.-dia. spherical), 4th—Army Ballistics Lab. shaped-charge accelerator and re-entr[illegible] Zimmey Corp. spin-stabilized velocity package which contains two [illegible] the 3rd and 4th stages mounted in reverse; 1,575-lbs., 27.5 ft.. [illegible]ges up to 120-km. altitude, two separate re-entries of different [illegible]aterials each with 11 km/sec. re-entry velocity, 15 degrees [illegible] at 75-km altitude; NASA

NAV[illegible] CENTER, POINT MUGU, CALIF.

SPAROAIR A[illegible] two-stage research rocket for use on F3B or F6B jet aircraft [illegible] 0.8 at 32,000 ft., 1st and 2nd—Aerojet Sparrow III's; 35-lb. pay[illegible] to [illegible]de of 65 n. mi.; used in Projects Tee Pee, Jane, and Night O[illegible] [illegible]ma generation, infrared and ultraviolet research, respectively; Na[illegible], General Motors Corp.

NAVAL ORDNANCE TEST STATION (NOTS, CHINA LAKE, CALIF.)

HOVERING ROCKET SYSTEM Two-stage research rocket, 1st—Thiokol Pershing TX-175 2nd stage, 2nd—NOTS to develop 19 x 3-ft.-dia. liquid engine (8,000-lb. thrust); weight, 700-lbs.; length, 27 ft.; recoverable payload to altitude of 65,000-50,000 ft.; 2nd stage carries command guidance, capable of stabilized 120-30 sec. hovering; two vehicles in development for upper-atmosphere research measurements and possibly surveillance use; Defense Atomic Support Agency

ROCKETDYNE DIV., NORTH AMERICAN AVIATION, INC.

AEOLUS 1-90 Single-stage solid sounding rocket (315-lb. thrust); weight, 41 lbs.; length, 4.25 ft.; 6-lb. payload to altitude of 90,000 ft.; launched from 5-in. gun or reinforced plastic shipping container; Navy

AEOLUS 1-200 Single-stage solid sounding rocket (500-lb. thrust); weight, 69.6 lbs.; length, 7.39 ft.; 6-8 lb. payload to altitude of 200,000 ft.; Navy

ROCKET POWER, INC. (RPI)

HOPI CHAFF DART Single-stage RPI 3.OKS-4000 Hopi-II solid motor; weight, 93 lbs.; length, 11 ft.; 11.5-lb. payload to altitude of 300,000 ft.; NASA

JUDI BALLOON DART Single-stage RPI 1.9KS-2100 Judi-I solid motor; weight, 33.7 lbs.; length, 9 ft.; 10-lb. payload (std. AF Mylar Robin Sphere) to 200,000 ft.; all services and foreign governments

JUDI CHAFF (OR PARACHUTE) DART Single-stage RPI 1.9KS-2100 Judi-I solid motor; weight, 30.3 lbs.; length, 8.6 ft.; 10-lb. payload to altitude of 240,000 ft.; all services, NASA and foreign governments

JUDI INSTRUMENTED DART Single-stage RPI 1.9KS-2100 Judi-I solid motor; weight, 33.7 lbs.; length, 9 ft.; 10-lb. payload to altitude of 220,000 ft.; all services and foreign governments

KISHA-JUDI Two-stage solid sounding rocket; 1st—RPI 4.4KS-4800 Kisha-I, 2nd—RPI 1.9KS-2100 Judi-III; weight, 221 lbs.; length, 14 ft.; 16-lb. payload to altitude of 480,000 ft.; Sandia Corp.

ORIOLE Single-stage RPI 5.5KS-6100 Kiva-I solid motor; weight, 236 lbs.; length, 13.6 ft.; 10-lb. payload to 473,000 ft. (Dart with 81.5 cu. in. payload volume); all services

PHOENIX-I Two-stage solid sounding rocket; 1st—RPI 5.5KS-6100 Kiva-I, 2nd—RPI 3.OKS-4000 Hopi-II; weight, 320 lbs.; length, 18 ft.; 10-lb. payload to altitude of 225 mi.; all services

RAVEN Single-stage RPI 8.5KS-1800 solid motor; weight, 100 lbs.; length, 10.8 ft.; 10-lb. payload to altitude of 250,000 ft.; under development for meteorological use by all services and NASA

SIDEWINDER-RAVEN Two-stage solid sounding rocket; 1st—Naval Propellant Plant, Sidewinder 1A, 2nd—RPI 8.5KS-1800; weight, 208 lbs.; length, 17 ft.; 20-lb. payload to altitude of 400,000 ft.; all services

THUNDERBIRD Single-stage RPI 15KS-4800 solid motor; weight, 445 lbs.; length, 16 ft.; 35-lb. payload to altitude of 620,000 ft.; under development for Navy

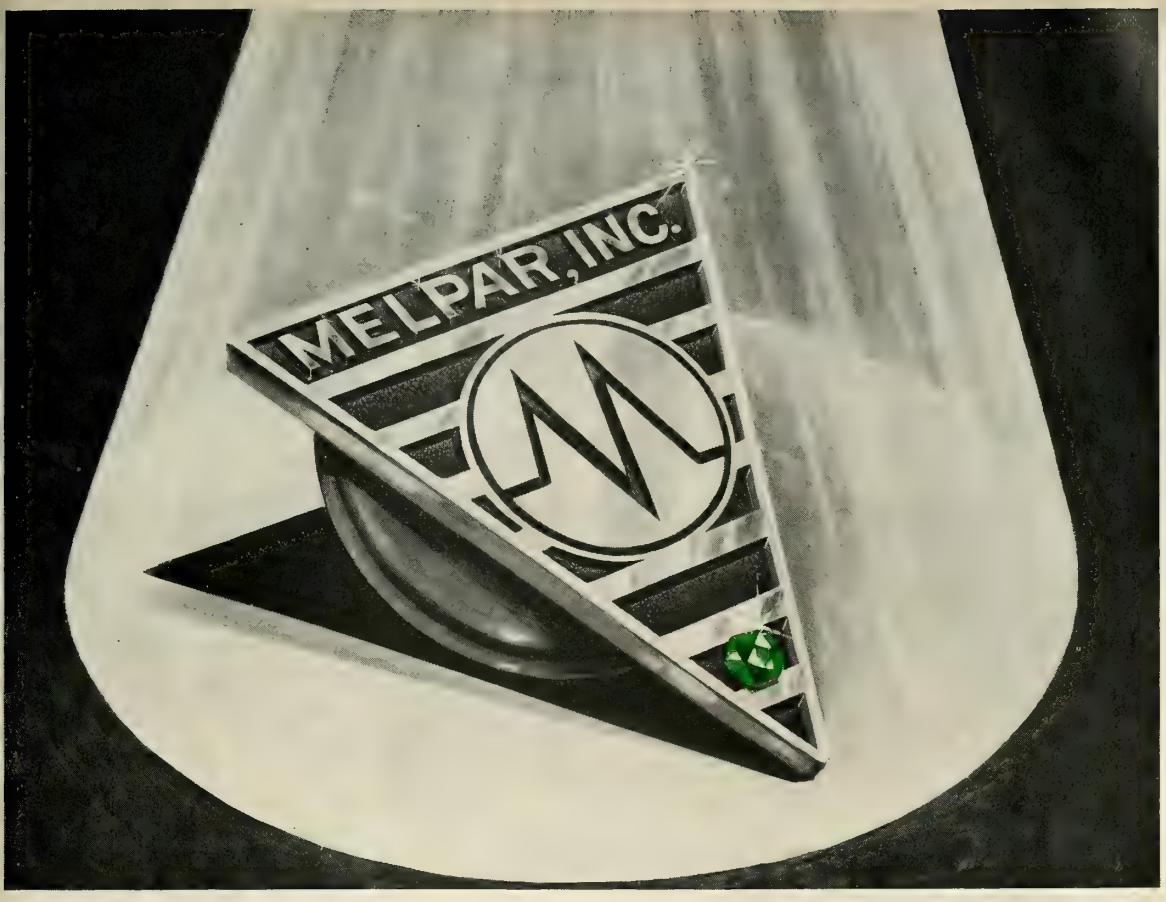
SANDIA CORP.

NITEHAWK 9 Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol TE-416 Tomahawk (10,000-lb. thrust); 9-in.-dia. payload section; 40-60 lb. payload to 200 mi. altitude; Mach 8.5; Atomic Energy Commission

SPACE-GENERAL CORP.

AEROBEE 100 Boosted single-stage sounding rocket; sustainer—liquid IRFNA & JP-4 engine (2,600-lb. thrust for 40 sec.), booster—Aerojet 2.5-KS-18,000 solid motor; weight, 1,470 lbs.; length, 25.75 ft.; 70-lb. payload to altitude of 80 mi.; tower-launched; max. acceleration 15.2 g; NASA, AF

AEROBEE 150 & 150A Boosted single-stage sounding rocket; sustainer—liquid IRFNA and aniline-furfuryl-alcohol mixture engine (4,100-lb. thrust for 51.8 sec.), booster—Aerojet 2.5KS-18,000 solid motor; weight, (150), 1,943 lbs.; length, (150), 29.67 ft.; weight, (150A), 1,941 lbs.; length, (150A), 30 ft.; 150-lb. payload to altitude of 152 mi.; max. acceleration 10.3 g; tower-launched; 150 version has 3 fins, 150A has 4 fins; altitude control and recovery systems available in both vehicles; NASA, AF, Navy, Kitt Peak Observatory



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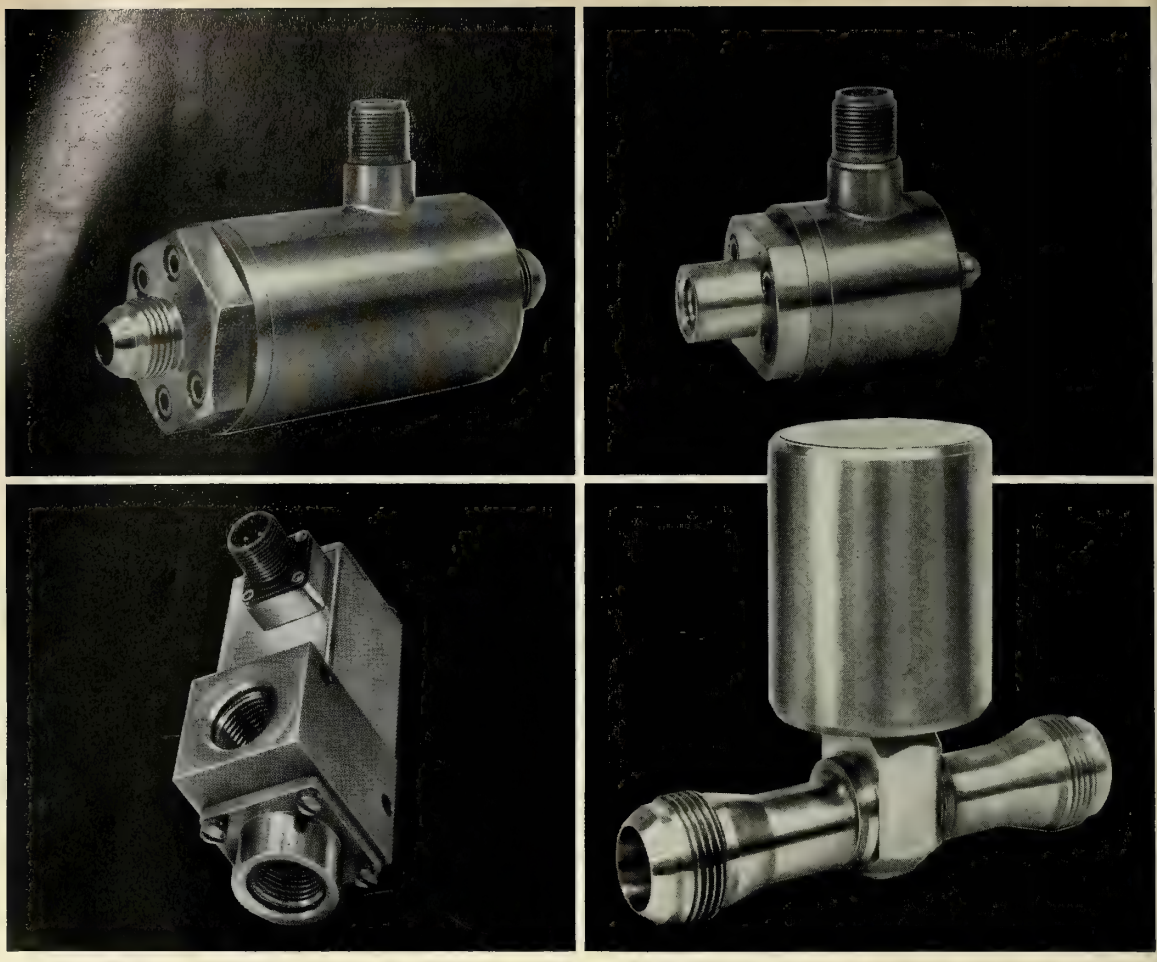

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AEROBEE 300 & 300A Two-stage sounding rocket; 1st—Aerobee 150 or 150A, 2nd—solid Aerojet Sparrow 1.8KS-7800; weight, 2,103 lbs.; length, (300), 33.00 ft., (300A), 33.30 ft.; 35-lb. payload to altitude of 300 mi.; max. acceleration 63.8 g; 300A has 4 fins; NASA, AF

AEROBEE 350 Design goal 150-lb. payload to altitude of nearly 300 mi.; under development for NASA

ASTROBEE 200 Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Aerojet 30KS-8000; weight, 2,601 lbs.; length, 26.42 ft.; 150-lb. payload to altitude of 170 mi.; max. acceleration 18.9 g; boom-launched; NASA, AF

ASTROBEE 250 Single-stage solid sounding rocket; Aerojet 28KS-57,000, optional auxiliaries—two Thiokol 1.5KS-35,000; weight, 10,358 lbs.; length, 34.17 ft.; 400-1,000-lb. payload to altitudes between 190-120 mi.; max. acceleration 13 g; boom-launched; NASA, AF, Navy

ASTROBEE 1500 Two-stage solid sounding rocket, 1st—Aerojet 28KS-57,000 with two Thiokol 1.5KS-35,000, 2nd—Aerojet 30KS-8000; weight, 11,493 lbs.; length, 34.17 ft.; 130-lb. payload to altitude of 1,300 mi.; max. acceleration 37 g; boom-launched; under development for NASA, AF, Sandia (replacement for NASA Journeymen A)

THIOKOL CHEMICAL CORP., ASTRO-MET DIV.

ADVANCED TERRIER-TOMAHAWK Two-stage solid sounding rocket, 1st—Hercules BT-3 Advanced Terrier (17,000-lb. thrust), 2nd—Thiokol TE-416 Tomahawk (10,000-lb. thrust); weight, 2,820 lbs.; length, 29.8 ft.; 200-lb. (12-in. dia.) payload to altitude of 185 mi. or 75-lb. (9-in. dia.) payload to altitude of 350 mi.; in development

NIKE-APACHE Two-stage solid sounding rocket, 1st—Hercules, M-5 Nike (48,700-lb. thrust), 2nd—Thiokol Apache TE-307 (5,900-lb. thrust), weight, 1,950 lbs.; length, 23 ft.; 50-lb. payload to altitude of 130 mi.; all services and NASA

NIKE-TOMAHAWK Two-stage solid sounding rocket, 1st—Hercules M-5 Nike (48,700-lb. thrust), 2nd—Thiokol TE-416 Tomahawk (10,000-lb. thrust); weight 1,977 lbs.; length, 29.7 ft.; 125-lb. payload to altitude of 200 mi.; all services and NASA

TOMAHAWK Single-stage solid sounding rocket, Thiokol TE-416 Tomahawk (10,000-lb. thrust); weight, 575 lbs.; length, 16.25 ft.; 45-lb. payload to altitude of 100 mi.; fin stabilized; all services and NASA

TOMAHAWK DART Single-stage solid sounding rocket; Thiokol TE-416 Tomahawk (10,000 lb. thrust); weight, 677 lbs., length 19.25 ft.; 125-lb. payload to 60 mi. altitude; all services and NASA

SATELLITES IN ORBIT

EXPLORER I (30.8 lbs.) U.S. Launched 2/1/58, est. life 7-10 years. Orbits Earth; perigee 340 km, apogee 1,567 km, period 104.2 min. Not transmitting.

VANGUARD I (3.25 lbs.) U.S. Launched 3/17/58, est. life 200 years. Orbits Earth; perigee 644 km, apogee 3,944 km, period 134.0 min. Not transmitting.

LUNA I (3,245 lbs.) USSR. Launched 1/2/59. In orbit around Sun on 450-day cycle. Not transmitting.

VANGUARD II (20.7 lbs.) U.S. Launched 2/17/59, est. life 100-250 years. Orbits Earth; perigee 548 km, apogee 3,293 km, period 125.4 min. Not transmitting.

PIONEER IV (13.4 lbs.) U.S. Launched 3/3/59. Orbits Sun on 398-day cycle. Not transmitting.

VANGUARD III (About 100 lbs.) U.S. Launched 9/18/59, est. life 50-150 years. Orbits Earth; perigee 512 km, apogee 3,716 km, period 129.8 min. Not transmitting.

EXPLORER VII (91.5 lbs.) U.S. Launched 10/13/59, est. life 30-40 years. Orbits Earth, perigee 556 km, apogee 1,069 km, period 101.1 min. Not transmitting.

PIONEER V (94.8 lbs.) U.S. Launched 3/11/60, est. life forever. Orbits Sun on 312-day period. Not transmitting.

TIROS I (270 lbs.) U.S. Launched 4/1/60, est. life 50-150 years. Orbits Earth; perigee 693 km, apogee 746 km, period 99.2 min. Not transmitting.

TRANSIT IB (265 lbs.) U.S. Launched 4/13/60, est. life 6 years. Orbits Earth; perigee 344 km, apogee 566 km, period 93.7 min. Not transmitting.

MIDAS II (5,000 lbs.) U.S. Launched 5/24/60, est. life 8-15 years. Orbits Earth; perigee 463 km, apogee 501 km, period 94.3 min. Not transmitting.

TRANSIT II-A (223 lbs.) U.S. Launched 6/22/60, est. life 50-200 years. Orbits Earth; perigee 613 km, apogee 1,058 km, period 101.6 min. Not transmitting.

NRL SOLAR RADIATION SATELLITE I (40 lbs.) U.S. Launched 6/22/60 with TRANSIT II-A, est. life 50-200 years. Orbits Earth; perigee 618 km, apogee 1,051 km, period 101.6 min. Not transmitting.

ECHO I (132 lbs.) U.S. Launched 8/12/60, est. life 2-16 years. Orbits Earth; perigee 924 km, apogee 1,852 km, period 113.5 min.

COURIER IB (500 lbs.) U.S. Launched 10/4/60, est. life 200-500 years. Orbits Earth; perigee 966 km, apogee 1,209 km, period 107.0 min. Not transmitting.

EXPLORER VIII (90 lbs.) U.S. Launched 11/3/60 by JUNO II, est. life 20-50 years. Orbits Earth; perigee 417 km, apogee 2,244 km, period 112.3 min. Not transmitting.

TIROS II (280 lbs.) U.S. Launched 11/23/60, est. life 200-500 years. Orbits Earth, perigee 619 km, apogee 728 km, period 98.2 min. Not transmitting.

SAMOS II (4,100 lbs.) U.S. Launched 1/31/61. Orbits Earth; perigee 466 km, apogee 544 km, period 94.7 min. Not transmitting.

VENUS PROBE (1,419 lbs.) USSR. Launched 2/12/61. Orbits Sun on 300-day cycle.

EXPLORER X (78 lbs.) U.S. Launched 3/25/61. Position uncertain. Not transmitting.

EXPLORER XI (82 lbs.) U.S. Launched 4/27/61. Orbits Earth; perigee 485 km, apogee 1,774 km, period 107.9 min. Not transmitting.

TRANSIT IVA (IVA, 175 lbs.; GREB III, 55 lbs. INJUN, 40 lbs.) U.S. Launched 6/29/61. Orbits Earth; TRANSIT, perigee 883 km, apogee 997 km, period 103.8 min. Transmitting 54.324; 150.400 mc. GREB-INJUN, perigee 882 km, apogee 998 km, period 103.8 min. Not transmitting. GREB III and INJUN failed to separate.

TIROS III (285 lbs.) U.S. Launched 7/12/61. Orbits Earth; perigee 747 km, apogee 807 km, period 100.4 min. Not transmitting.

MIDAS III (3,500 lbs.) U.S. Launched 7/12/61. Orbits Earth; perigee 3,321 km, apogee 3,571 km, period 161.5 min. Not transmitting.

EXPLORER XII (83 lbs.) U.S. Launched 8/16/61. Current elements not maintained. Not transmitting.

MIDAS IV (3,500 lbs.) U.S. Launched 10/21/61. Orbits Earth; perigee 3,495 km, apogee 3,759 km, period 166.0 min. Not transmitting.

TRANSIT IVB (200 lbs.) U.S. Launched 11/15/61. Orbits Earth; perigee 959 km, apogee 1,100 km, period 105.8 min. Damaged by radiation from U.S. July 9, 1962, nuclear test.

TRAAC (240 lbs.) U.S. Launched 11/15/61 piggyback on TRANSIT IVB. Orbits Earth, perigee 953 km, apogee 1,108 km, period 105.8 min. Damaged by radiation from U.S. July 9, 1962, nuclear test.

RANGER III (727 lbs.) U.S. Launched 1/26/62. Orbits Sun on 406.4-day cycle; lunar probe failed to impact, went into heliocentric orbit. Not transmitting.

TIROS IV (285 lbs.) U.S. Launched 2/8/62. Orbits Earth; perigee 707 km, apogee, 844 km, period 100.4 min. Not transmitting.

ORBITING SOLAR OBSERVATORY (440 lbs.) U.S. Launched 3/7/62. Orbits Earth; perigee 553 km, apogee 580 km, period 96.0 min. Not transmitting.

COSMOS 2 (Weight unknown) USSR. Launched 4/6/62. Orbits Earth; perigee, 183 km, apogee 549 km, period 91.8 min. Transmission data not known.

ARIEL I (132 lbs.) U.S.-U.K. Launched 4/26/62. Orbits Earth; perigee 389 km, apogee 1,169 km, period 100.4 min. Damaged by radiation from U.S. July 9, 1962, nuclear test. Transmitting 136.405 mc.

TIROS V (285 lbs.) U.S. Launched 6/19/62. Orbits Earth; perigee 591 km, apogee 972 km, period 100.5 min. Not transmitting.

TELSTAR I (170 lbs.) U.S. Launched 7/10/62. Orbits Earth; perigee 946 km, apogee 5,642 km, period 157.8 min. Not transmitting.

MARINER II (447 lbs.) U.S. Launched 8/27/62. Heliocentric orbit on 348-day cycle. Planetary spacecraft came within 21,594 mi. of Venus Dec. 14, 1963.

TIROS VI (281 lbs.) U.S. Launched 9/18/62. Orbits Earth; perigee 686 km, apogee 710 km, period 98.7 min. Not transmitting.

ALOUETTE (300 lbs.) Canada. Launched 9/29/62. Orbits Earth; perigee 1,000 km, apogee 1,035 km, period 105.5 min. Satellite built by Canada, launched by U.S. Transmitting 136.593; 136.077 mc.

EXPLORER XIV (89 lbs.) U.S. Launched 10/2/62. Current elements not maintained. Not transmitting.

RANGER V U.S. Launched 10/18/62. Heliocentric orbit.

EXPLORER XI (98 lbs.) U.S. Launched 10/27/62. Orbits Earth; perigee 307 km, apogee 17,388 km, period 311.8 min. Not transmitting.

ANNA IB (350 lbs.) U.S. Launched 10/31/62. Orbits Earth; perigee 1,074 km, apogee 1,185 km, period 107.9 min. Transmitting 162.324 mc.

INJUN III (40 lbs.) U.S. Launched 12/13/62. Orbiting Earth; perigee 235 km, apogee 2,322 km, period 111.1 min. Not transmitting.

RELAY I (172 lbs.) U.S. Launched 12/13/62. Orbits Earth; perigee 1,390 km, apogee 7,368 km, period 185.1 min. Transmitting 136.140; 136.621 mc.

EXPLORER XVI (222 lbs.) U.S. Launched 12/16/62. Orbits Earth; perigee 745 km, apogee 1,184 km, period 104.4 min. Not transmitting.

TRANSIT V-A. (135 lbs.) U.S. Launched 12/19/62. Orbits Earth; perigee 697 km, apogee 740 km, period 99.1 min. Not transmitting.

SYNCOM I (86 lbs.) U.S. Launched 2/14/63. Orbits Earth. Current elements not maintained. Not transmitting; communications lost when satellite went into orbit.

LUNA IV (3,135 lbs.) USSR. Launched 4/2/63. Barycentric orbit; position uncertain.

EXPLORER XVII (405 lbs.) U.S. Launched 4/3/63. Orbits Earth; perigee 252 km, apogee 687 km, period 94.0 min. Not transmitting.

TELSTAR II (175 lbs.) U.S. Launched 5/7/63. Orbits Earth; perigee 961 km, apogee 10,811 km, period 225.3 min. Not transmitting.

TIROS VII (297 lbs.) U.S. Launched 6/19/63. Orbits Earth; perigee 623 km, apogee 648 km, period 97.4 min. Transmitting 136.234; 136.923 mc.

RESEARCH SATELLITE FOR GEOPHYSICS (Weight unknown) U.S. Launched 6/28/63. Orbits Earth; perigee 414 km, apogee 1,294 km, period 102.0 min. Not transmitting.

SYNCOM II (86 lbs.) U.S. Launched 7/26/63. Orbits Earth; perigee 35,799 km, apogee 35,810 km, period 1,436.0 min. Transmitting 136.980; 136.467; 1814.069; 1815.177 mc.

POLYOT I (Weight unknown) USSR. Launched 11/1/63. Orbits Earth; perigee 338 km, apogee 1,396 km, period 102.3 min. Not transmitting.

EXPLORER XVIII (138 lbs.) U.S. Launched 11/27/63. Orbits Earth; perigee 4,385 km, apogee 192,042 km, period 5,610.7 min. Not transmitting.

CENTAUR II (10,700 lbs.) U.S. Launched 11/27/63. Orbits Earth; perigee 473 km, apogee 1,775 km, period 107.8 min. Not transmitting.

EXPLORER XIX (15 lbs.) U.S. Launched 12/19/63. Orbits Earth; perigee 625 km, apogee 2,312 km, period 115.3 min. Not transmitting.

TIROS VIII (265 lbs.) U.S. Launched 12/21/63. Orbits Earth; perigee 701 km, apogee 755 km, period 99.4 min. Transmitting 136.233; 136.925 mc.

GRAVITY-GRADIENT STABILIZATION EXPERIMENT (Weight unknown) U.S. Launched 1/11/64. Orbits Earth; perigee 911 km, apogee 934 km, period 103.4 min. Not transmitting.

EXTRA-GALACTIC RADIATION SATELLITE (Weight unknown) U.S. Launched 1/11/64. Orbits Earth; perigee 910 km, apogee 934 km, period 103.4 min. Transmitting 136.802 mc.

SOLAR RADIATION SATELLITE (Weight unknown) U.S. Launched 1/11/64. Orbits Earth; perigee 913 km, apogee 933 km, period 103.5 min. Transmitting 136.886 mc.

RELAY II (172 lbs.) U.S. Launched 1/21/64. Orbits Earth; perigee 2,020 km, apogee 7,479 km, period 194.7 min. Transmitting 136.142; 136.622 mc.

ECHO II (547 lbs.) U.S. Launched 1/25/64. Orbits Earth; perigee 1,007 km, apogee 1,293 km, period 108.3 min. Transmitting 136.020, 136.170 mc.

SATURN V (37,700 lbs.) U.S. Launched 1/29/64. Orbits Earth; perigee 253 km, apogee 562 km, period 92.8 min. Not transmitting.

ELEKTRON I (Weight unknown) USSR. Launched 1/30/64. Orbits Earth; perigee 402 km, apogee 7,115 km, period 169.3 min. Transmission data not known.

ELEKTRON II (Weight unknown) USSR. Launched 1/30/64. Orbits Earth; perigee 1,257 km, apogee, 67,164 km, period 1,356.3 min. Transmission data not known.

ARIEL II (150 lbs.) U.S.-U.K. Launched 3/27/64. Orbits Earth; perigee 282 km, apogee 1,245 km, period 100.1 min. Transmitting 136.556 mc.

POLYOT II (Weight unknown) USSR. Launched 4/12/64. Orbits Earth; perigee 291 km, apogee 422 km, period 91.7 min. Transmission data not known.

ELEKTRON III (Weight unknown) USSR. Launched 7/11/64. Orbits Earth; perigee 403 km, apogee 7,022 km, period 168.1 min. Transmission data not known.

ELEKTRON IV (Weight unknown) USSR. Launched 7/11/64. Orbits Earth; perigee 870 km, apogee 65,847 km, period 1,313.8 min. Transmission data not known.

VELA III (319 lbs.) U.S. Launched 7/17/64. Orbits Earth; perigee 102,407 km, apogee 104,188 km, period 6,024.5 min. Not transmitting.

VELA IV (319 lbs.) U.S. Launched 7/17/64. Orbits Earth; perigee 93,567 km, apogee 112,550 km, period 6,004.9 min. Not transmitting.

TRS 6 (4.5 lbs.) U.S. Launched 7/17/64. Orbits Earth; perigee 319 km, apogee 104,001 km, period 2,349.4 min. Not transmitting.

SYNCOM III (86 lbs.) U.S. Launched 8/19/64. Orbits Earth; perigee 35,784 km, apogee 35,792 km, period 1,436.2 min. Transmitting 136.470; 136.980; 1,820.177; 1,815.794; 1,814.931 mc.

COSMOS 41 (Weight unknown) USSR. Launched 8/22/64. Orbits Earth; perigee 733 km, apogee 39,470 km, period 714.7 min. Transmission data not known.

COSMOS 42 (Weight unknown) USSR. Launched 8/22/64. Orbits Earth; perigee 223 km, apogee 761 km, period 94.5 min. Transmission data not known.

COSMOS 43 (Weight unknown) USSR. Launched 8/22/64. Earth orbit; perigee 225 km, apogee 754 km, period 94.5 min. Transmission data not known.

EXPLORER XX (97 lbs.) U.S. Launched 8/25/64. Orbits Earth; perigee 871 km, apogee 1,019 km, period 103.9 min. Transmitting 136.326; 136.350; 136.680 mc.

NIMBUS I (830 lbs.) U.S. Launched 8/28/64. Orbits Earth; perigee 429 km, apogee 930 km, period 98.3 min. Not transmitting.

COSMOS 44 (Weight unknown) USSR. Launched 8/28/64. Orbits Earth; perigee 596 km, apogee 876 km, period 99.5 min. Transmission data not known.

Centrinauts: a new breed of men

Despite copy book maxims, you *can* make progress while going around in circles or lying flat on your back. Several U.C.L.A. college students, dubbed "The Centrinauts," proved this fact recently in the Douglas Biotechnology Laboratory.

WEIGHTLESSNESS is simulated by floating for hours in a warm pool. The Centrinaut then takes his place in the centrifuge and is subjected to high G forces to determine whether he can "take" the strains of re-entry.

Their reactions—heart-beat, muscle-tone, blood-pressure and others—are being taped under conditions simulating those on space missions. And Douglas scientists are gaining valuable insights from them on how astronauts will react in current manned space programs.

But manned spacecraft require knowledge in many scientific areas. So a wide array of Douglas laboratories are doing advanced research in fields ranging from man-machine relationships to inter-planetary space flight.

DOUGLAS

MISSILE & SPACE SYSTEMS DIVISION

Why is Hamilton Standard qualified for MOL life support?

A series of space life support accomplishments makes Hamilton Standard the logical choice for developing the Manned Orbital Laboratory life support system.

LEM — Hamilton Standard has designed, developed and is delivering second generation advanced life support system hardware for the Grumman Lunar Excursion Module.

EMU—Hamilton Standard is prime contractor to NASA's Manned Spacecraft Center for the Extra-vehicular Mobility Unit of Project Apollo. EMU is a complete integrated space-pressure vessel with a self-contained life support system. Prototype hardware has already been delivered.

BIOSATELLITE—Hamilton Standard is designing, developing, and will deliver the first two-gas, 30-day, fully automatic gas management assembly, to be used in the General Electric Biosatellite.

CO_2 REMOVAL—Hamilton Standard has designed and developed a regenerable molecular sieve CO_2 removal system. This system has successfully operated under MOL conditions for 60 consecutive days. Over 5,300 test hours have been logged.

Hamilton Standard is the recognized leader in molecular sieve technology.

Hamilton Standard can efficiently and quickly adapt over 80% of the LEM project components to the MOL program and is ready to start now.

Hamilton Standard DIVISION OF UNITED AIRCRAFT CORPORATION

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ENVIRONMENTAL CONTROLS • LIFE SUPPORT SYSTEMS • SECONDARY PROPULSION • TURBOMACHINERY • PROPELLERS • ATTITUDE CONTROLS • ELECTRONICS
STABILIZATION SYSTEMS • STARTERS • FUEL AND AIR INDUCTION CONTROLS • GROUND SUPPORT EQUIPMENT • OVERHAUL AND REPAIR • ELECTRON BEAM MACHINES

ORBITING GEOPHYSICAL OBSERVATORY I (1,073 lbs.) U.S. Launched 9/5/64. Orbits Earth; perigee 4,274 km, apogee 145,485 km, period 3,842.0 min. Transmitting 136.200; 400.205; 400.850; 136.147 mc.

EXPLORER XXI (136 lbs.) U.S. Launched 10/4/64. Orbits Earth; perigee 917 km, apogee 94,288 km, period 2,080.3 min. Not transmitting.

EXPLORER XXII (116 lbs.) U.S. Launched 10/10/64. Orbits Earth; perigee 892 km, apogee 1,077 km, period 104.8 min. Transmitting 136.171; 162.324 mc.

COSMOS 49 (weight unknown) USSR. Launched 10/24/64. Orbits Earth; perigee 242 km, apogee 335 km, period 90.3 min. Transmission data not known.

LES I (69 lbs.) U.S. Launched 2/11/65. Orbits Earth; perigee 2,783 km, apogee 2,803 km, period 145.7 min. Not transmitting.

MARINER III (575 lbs.) U.S. Launched 11/5/64. Heliocentric orbit; Not transmitting.

EXPLORER XXIII (295 lbs.) U.S. Launched 11/6/64. Orbits Earth; perigee 458 km, apogee 984 km, period 99.2 min. Transmitting 136.079; 136.858 mc.

EXPLORER XXIV (19 lbs.) U.S. Launched 11/21/64. Orbits Earth; perigee 536 km, apogee 2,445 km, period 115.8 min. Transmitting 136.712 mc.

EXPLORER XXV (90 lbs.) U.S. Launched 11/21/64. Orbits Earth; perigee 530 km, apogee 2,494 km, period 116.2 min. Transmitting 136.292; 136.860 mc.

MARINER IV (575 lbs.) U.S. Launched 11/28/64. Helipcentric orbit. Not transmitting.

ZOND II (Weight unknown) USSR. Launched 11/30/64. Heliocentric orbit.

COSMOS 51 (Weight unknown) USSR. Launched 12/9/64. Orbits Earth; perigee 253 km, apogee 435 km, period 91.5 min. Transmission data not known.

SAN MARCO (254 lbs.) Italy. Launched 12/15/64. Orbits Earth; perigee 199 km, apogee 552 km, period 92.2 min. Not transmitting.

EXPLORER XXVI (101 lbs.) U.S. Launched 12/21/64. Orbits Earth; perigee 256 km, apogee 26,181 km, period 455.1 min. Transmitting 136.274 mc.

TIROS IX (305 lbs.) U.S. Launched 1/22/65. Orbits Earth; perigee 724 km, apogee 2,565 km, period 119.2 min. Transmitting 136.232; 136.919 mc.

COSMOS 53 (Weight unknown) USSR. Launched 1/30/65. Orbits Earth; perigee 220 km, apogee 1,067 km, period 97.6 min. Transmission data not known.

ORBITING SOLAR OBSERVATORY II (545 lbs.) U.S. Launched 2/3/65. Orbits Earth; perigee 544 km, apogee 631 km, period 96.5 min. Transmitting 136.712 mc.

PEGASUS I (23,000 lbs.) U.S. Launched 2/16/65. Orbits Earth; perigee 502 km, apogee 726 km, period 97.0 min. Transmitting 136.410; 136.890 mc.

COSMOS 54 (Weight unknown) USSR. Launched 2/21/65. Orbits Earth; perigee 264 km, apogee 1,684 km, period 104.6 min. Transmission data not known.

COSMOS 55 (Weight unknown) USSR. Launched 2/21/65. Orbits Earth; perigee 267 km, apogee 1,703 km, period 104.8 min. Transmission data not known.

COSMOS 56 (Weight unknown) USSR. Launched 2/21/65. Orbits Earth; perigee 265 km, apogee 1,630 km, period 104.0 min. Transmission data not known.

COSMOS 58 (Weight unknown) USSR. Launched 2/26/65. Orbits Earth; perigee 564 km, apogee 646 km, period 96.8 min. Transmission data not known.

GREB VI (Weight unknown) U.S. Launched 3/9/65. Orbits Earth; perigee 908 km, apogee 942 km, period 103.5 min. Not transmitting.

GRAVITY GRADIENT SATELLITE II (Weight unknown) U.S. Launched 3/9/65. Orbits Earth; perigee 907 km, apogee 941 km, period 103.5 min. Not transmitting.

GRAVITY GRADIENT SATELLITE III (Weight unknown) U.S. Launched 3/9/65. Orbits Earth; perigee 910 km, apogee 940 km, period 103.5 min. Transmitting 136.767 mc.

SOLAR RADIATION SATELLITE (Weight unknown) U.S. Launched 3/9/65. Orbits Earth; perigee 908 km, apogee 942 km, period 103.5 min. Transmitting 136.801 mc.

EGRS (SECOR) III (40 lbs.) U.S. Launched 3/9/65. Orbits Earth; perigee 906 km, apogee 942 km, period 103.5 min. Transmitting 136.842 mc.

OSCAR III (33 lbs.) U.S. Launched 3/9/65. Orbits Earth; perigee 914 km, apogee 935 km, period 103.5 min. Not transmitting.

SURCAL SATELLITE (Weight unknown). U.S. Launched 3/9/65. Orbits Earth; perigee 908 km, apogee 940 km, period 103.5 min. Not transmitting.

EGRS (SECOR) II (40 lbs.) U.S. Launched 3/11/65. Orbits Earth; perigee 289 km, apogee 1,015 km, period 97.7 min. Not transmitting.

COSMOS 61 (Weight unknown) USSR. Launched 3/15/65. Orbits Earth; perigee 267 km, apogee 1,692 km, period 104.7 min. Transmission data not known.

COSMOS 61 (Weight unknown) USSR. Launched 3/15/65. Orbits Earth; perigee 264 km, apogee 1,677 km, period 104.5 min. Transmission data not known.

COSMOS 63 (Weight unknown) USSR. Launched 3/15/65. Orbits Earth; perigee 264 km, apogee 1,625 km, period 104.0 min. Transmission data not known.

EGRS (SECOR) IV (40 lbs.) U.S. Launched 4/3/65. Orbits Earth; perigee 1,267 km, apogee 1,322 km, period 111.4 min. Not transmitting.

EARLY BIRD (85 lbs.) U.S. Launched 4/6/65. Orbits Earth; perigee 35,019 km, apogee 36,590 km, period 1,437.0 min.

MOLNYA I (Weight unknown) USSR. Launched 4/23/65. Orbits Earth; perigee 545 km, apogee 39,932 km, period 720.3 min. Transmission data not known.

EXPLORER XXVII (134 lbs.) U.S. Launched 4/29/65. Orbits Earth; perigee 936 km, apogee 1,316 km, period 107.8 min. Transmitting 136.739; 162.324 mc.

PEGASUS II (3,200 lbs.) U.S. Launched 5/25/65. Orbits Earth; perigee 510 km, apogee 733 km, period 97.2 min. Transmitting 136.410; 136.890 mc.

EXPLORER XXVIII (130 lbs.) U.S. Launched 5/29/65. Orbits Earth; perigee 196 km, apogee 264,247 km, period 8,558.8 min. Transmitting 136.125 mc.

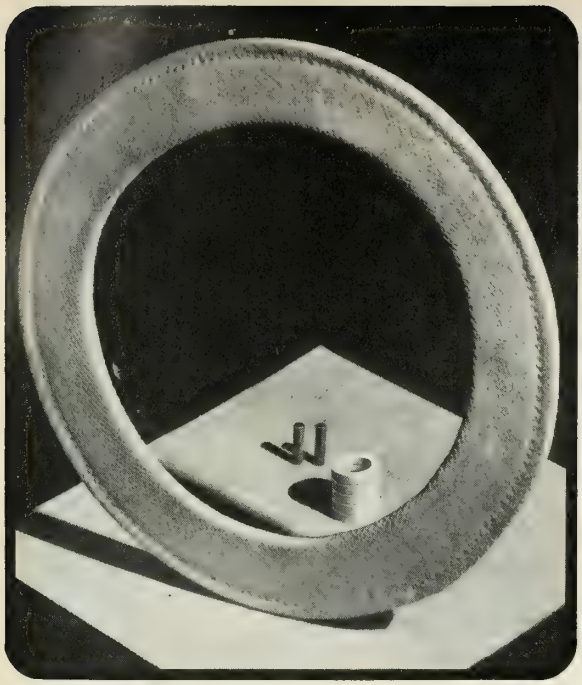
LUNA VI (Weight unknown) USSR. Launched 6/8/65. Heliocentric orbit.

COSMOS 69 (Weight unknown) USSR. Launched 6/25/65. Orbits Earth; perigee 206 km, apogee 305 km, period 89.7 min. Transmission data not known.

SECRET AIR FORCE SATELLITES

- Launched 7/2/64. Thrust-Augmented Thor-Agena D. Orbits Earth; perigee 496 km, apogee 528 km, period 94.8 min.
- Launched 8/14/64. Atlas-Agena D. Orbits Earth; perigee 270 km, apogee 3,692 km, period 126.7 min.
- Launched 10/6/64. Thor-Ablestar. Orbits Earth; perigee 1,050 km, apogee 1,090 km, period 106.6 min.
- Launched 10/6/64. Thor-Ablestar. Orbits Earth; perigee 1,053 km, apogee 1,085 km, period 106.6 min.
- Launched 10/6/64. Thor-Ablestar. Orbits Earth; perigee 1,055 km, apogee 1,087 km, period 106.6 min.
- Launched 11/4/64. Thrust-Augmented Thor-Agena D. Orbits Earth; perigee 511 km, apogee 524 km, period 94.9 min.
- Launched 12/13/64. Thor-Ablestar. Orbits Earth; perigee 1,026 km, apogee 1,089 km, period 106.3 min. Transmitting 136.650; 162.324 mc.
- Launched 12/13/64. Thor-Ablestar. Orbits Earth; perigee 1,024 km, apogee 1,091 km, period 106.3 min. Transmitting 150.400 mc.
- Launched 1/19/65. Thor-Altair. Orbits Earth; perigee 466 km, apogee 827 km, period 97.6 min.
- Launched 3/18/65. Thor-Altair. Orbits Earth; perigee 526 km, apogee 759 km, period 97.5 min.
- Launched 4/3/65. (Booster unknown). Orbits Earth; perigee 1,271 km, apogee 1,323 km, period 111.5 min.
- Launched 5/6/65. (Booster unknown). Orbits Earth; perigee 2,777 km, apogee 3,746 km, period 157.0 min.
- Launched 5/18/65. Thor-Agena. Orbits Earth; perigee 192 km, apogee 243 km, period 88.9 min.
- Launched 5/20/65. (Booster unknown). Orbits Earth; perigee 556 km, apogee 964 km, period 100.0 min.
- Launched 6/9/65. (Booster unknown). Orbits Earth; perigee 176 km, apogee 355 km, period 89.9 min.

Which of these R/M characteristics



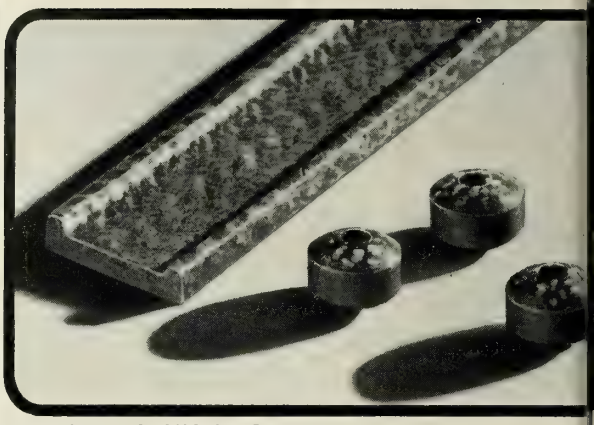
Cryogenic Materials (LOX compatible)

Characteristics: Resilient; zero moisture absorption; excellent aging properties; chemical, fuel and solvent resistant; anti-stick; can be used to —423°F.

R/M 601—unsintered TFE-impregnated woven asbestos fabric—for use as gaskets on pipe lines, valves, ducting and pressed metal covers.

R/M RL-279—unsintered TFE-impregnated woven asbestos folded gasket —made from R/M 601 and used where exposed cut fibers are undesirable.

R/M 3-TF00 and 4-TF00—unsintered TFE-impregnated braided asbestos valve stem packings—for use on propellant lines.

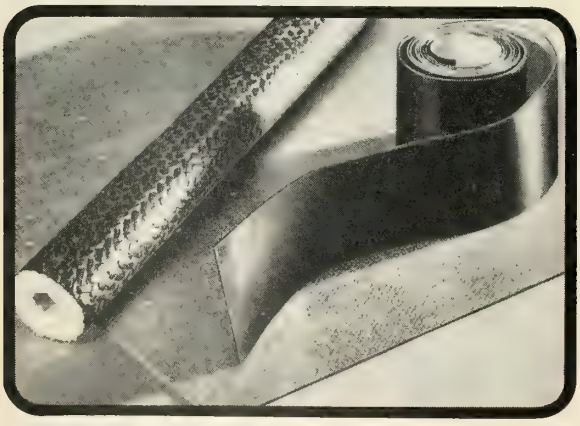


TFE-asbestos Anti-Friction Components

Characteristics: Low coefficient of friction, excellent insulating qualities in range of —450° to 500°F; chemical, fuel and solvent resistant; zero moisture absorption.

R/M RL-816 Channel Tape—sintered TFE-impregnated, wire-inserted, braided asbestos—for use as clamp liner or rub strip on cable controls and electrical harnesses.

R/M RL-742 Grommet—sintered TFE-impregnated braided asbestos, die-formed and slit—for use as guide when cable controls pass through compartment closures.



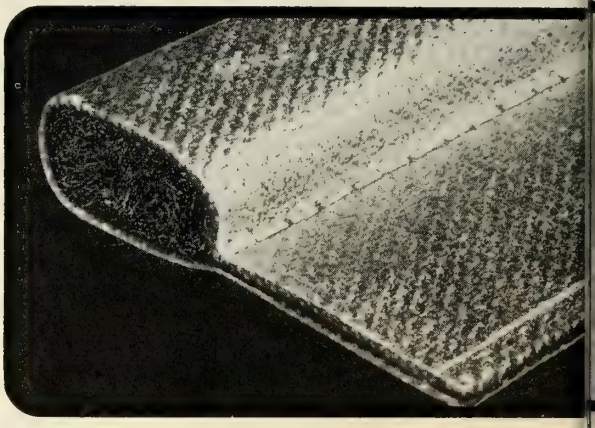
Blast Barrier Materials

Characteristics: Withstands blast temperatures and velocities; resist LOX and N_2O_4 propellant splashes.

R/M Ablatape®—homogeneous or asbestos-reinforced—for wrapping umbilical and propellant lines, valves, etc., in blast area. Conforms to irregular shapes and is easy to install.

R/M Ablatube®—homogeneous or asbestos-reinforced—for slip-on covering of umbilical and propellant lines in blast area.

R/M RL-638—wire-inserted woven asbestos fabric—for wrapping and clamping around valves, regulators and other equipment near launch pad. Is highly reflective, will not support combustion.



Tadpole Seal

Characteristics: Metallic mesh helps provide resiliency at temperatures above limits of elastomeric materials; resists penetration of 2000°F flame for 15-30 minutes.

R/M RL-819 Seal—metallic mesh core with a woven asbestos jacket coated on inside with a high temperature, resilient elastomer and on the outside with a highly reflective agent—used as a seal where high resiliency is required.

Complete technical information on R/M materials for missile and rocket applications is available on request. Any of these high reliability products can be tailored to your requirements. Write R/M Packing Division, Raybestos-Manhattan, Inc., Passaic, N. J.

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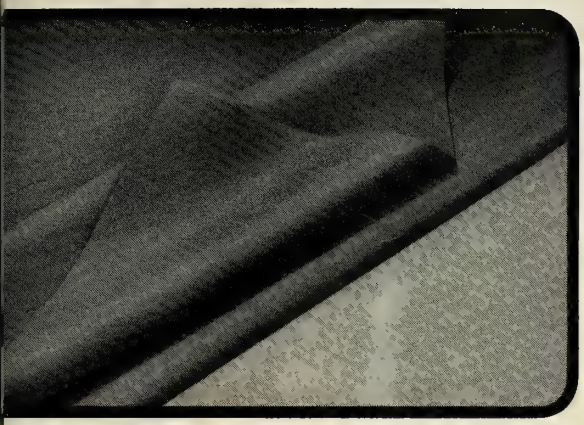
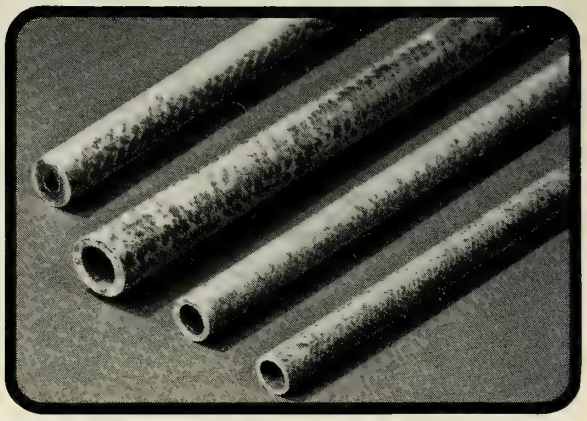
engineered materials provide the you need for your application?



Radioactive Shielding Material

Characteristics: Shields gamma rays; extremely flexible; has ⅓ the radioactive absorption capacity and ⅓ the weight of a pure lead sheet of same thickness; is an antivibration and sound absorption material.

R/M RL-1736—neoprene/lead sheet material—used to protect against radioactivity when wrapped around pipe or draped over unusual shapes. Also as a vibration and sound dampener.

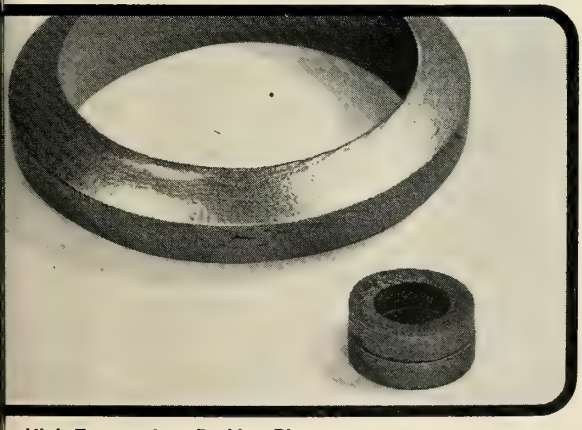


Protective Covering Material

Characteristics: Flexible; zero moisture absorption; excellent aging properties; chemical, fuel and solvent resistant; anti-stick; can be used to —423°F.

R/M RL-209—Sintered TFE-impregnated Braided Asbestos Tubing—a protective covering for pipe hangers, battery and other electrical or mechanical cables.

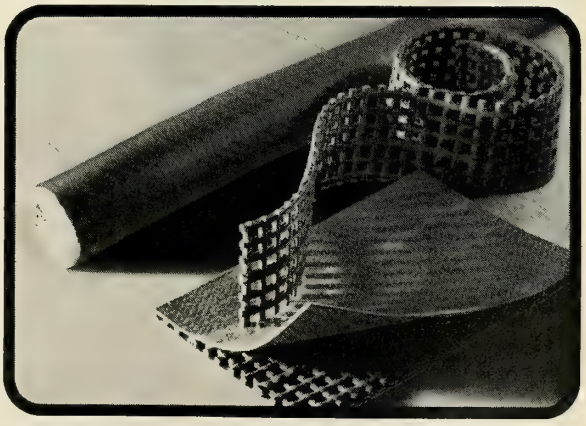
Low coefficient of friction allows freedom of movement through expansion and contraction. Prevents electrolytic reaction when used with dissimilar metals as well as degradation of metals in a corrosive atmosphere.



High Temperature Packing Rings

Characteristics: Resist temperatures to 1000°F, have minimum volume loss.

R/M CL-7029—AAA grade wire-inserted, braided asbestos containing a lubricant with a minimum amount of organics. Used as valve packing, and to prevent leakage in telescoping joints on hot lines such as exhaust manifolds.



Silicone Sponge Materials

Characteristics: Sensitive, lightweight, good aging qualities, ozone resistant, can be used in temperatures from —100 to 300°F.

R/M RL-524—Silicone Sponge Rod—used as a compartment seal, insulation, or as the core of a tadpole seal.

R/M Silicone Sponge Waffle Insulating Material—tape or sheet—is an effective insulating material, provides good shock absorbing qualities. When sandwiched between two sheets of RL-638, it becomes a light-weight insulating blanket with a highly reflective surface.

RM

MECHANICAL PACKINGS • GASKET MATERIALS • SPECIALTY PRODUCTS

RAYBESTOS-MANHATTAN, INC.

Circle No. 10 on Subscriber Service Card

Alfa (RUR-4) (Navy)

TYPE: Antisubmarine rocket-boosted depth charge

STATUS: Operational

PRIME CONTRACTOR: Navy

FRAME CONTRACTOR: Avco

FRAME CONFIGURATION: Length, 8.5 ft.; diameter, 12.75 in.; weight, 500 lbs.

PROPULSION CONTRACTOR: Naval Propellant Plant

PROPULSION TYPE: Solid rocket

GUIDANCE CONTRACTOR: None

GUIDANCE TYPE: Free-flight

PAYLOAD: High-explosive depth charge

REMARKS: Operational aboard cruisers and destroyers since 1952; launched from turret-mounted guns to a maximum of 1,000 yds.

Asroc (RUR-5A) (Navy)

TYPE: Antisubmarine rocket-boosted torpedo

STATUS: Operational on escort ships, destroyers & cruisers

PRIME CONTRACTOR: Honeywell
FRAME CONTRACTOR: Honeywell/ General Mills

FRAME CONFIGURATION: Length, 15 ft.; torpedo-warhead length, 100 in.; diameter, 12 in.; span, 2.5 ft.; weight 1,000 lbs.

PROPULSION CONTRACTOR: Naval Propellant Plant

PROPULSION TYPE: Solid rocket
GUIDANCE CONTRACTOR: Sangamo Electric

GUIDANCE TYPE: Sonar detection in torpedo nose; type SQS-23; unguided during aerial flight

PAYLOAD: General Electric Mk 44 homing torpedo with nuclear warhead or conventional depth charge

EQUIPMENT CONTRACTORS: General Precision Librascope Group, digital computer for fire control; Universal Match Co., launcher

PERFORMANCE: Range, 1 to 5 n. mi.; speed about Mach 1

REMARKS: Initially operational in 1960; replaces Hedgehogs on surface ships; one "live" warhead fired during Pacific nuclear tests; advanced version under development; may be delayed because of limited ranges of ASW detection equipment

ASROC

Astor (Navy)

TYPE: Rocket-boosted antisubmarine torpedo

STATUS: Production

PRIME CONTRACTOR: Westinghouse Electric

FRAME CONTRACTOR: Westinghouse Electric

FRAME CONFIGURATION: Length (less booster), 20 ft.; weight, over 2,000 lbs.

PROPULSION TYPE: Solid propellant

GUIDANCE TYPE: Wire-guided

PAYLOAD: Nuclear warhead on Mk 45 torpedo

PERFORMANCE: Range, about 11 n. mi.

REMARKS: To be deployed aboard hunter-killer subs

Atlas (CGM-16D, E), (HGM-16F) (Air Force)

TYPE: ICBM

STATUS: Phased out of operational inventory, June 30, 1965

PRIME CONTRACTOR: TRW Systems Group, systems engineering & technical direction

FRAME CONTRACTOR: General Dynamics/Astronautics

FRAME TYPE & CONFIGURATION: Stainless-steel pressurized tankage; length, 82.5 ft.; tankage diameter, 10 ft.; base diameter, 16 ft.; launch weight, 269,000 lbs.

PROPULSION CONTRACTOR: Rocketdyne

PROPULSION TYPE: Two liquid-propellant booster engines & one sustainer; boosters produce 165,000 lbs. thrust each and sustainer produces 60,000 lbs.; uses LOX & RP-1 propellants

GUIDANCE CONTRACTOR: GE/Burroughs for Series D; American Bosch Arma for Series E and F

GUIDANCE TYPE: Radio-inertial for Series D (first four squadrons) and all-inertial for remaining nine squadrons

PAYLOAD: Nuclear warhead; reentry vehicles by GE and Avco

GROUND EQUIPMENT CONTRACTORS: General Dynamics, launch facilities integration; propellant loading system, Arthur D. Little Co.; propellant utilization system, Acoustica Associates

PERFORMANCE: Range, 9,000 mi.; speed, over 16,000 mph

REMARKS: Missiles will be used in sub-orbital R&D programs over next 5 years

Close-Support Assault Weapon (Navy)

TYPE: Ship-to-shore

MISSION: Close support of amphibious landings

PRIME CONTRACTOR: Navy Bureau of Weapons and Johns Hopkins Applied Physics Lab

CONFIGURATION: Outside dimensions of the missile are to be compatible with Terrier shipboard installations

PROPULSION: Solid

GUIDANCE CONTRACTOR: Norden Div., United Aircraft

GUIDANCE: Inertial with a single-degree-of-freedom gyro terminal guidance

PERFORMANCE: Range of at least 30 miles

PAYLOAD: High-explosive warhead

REMARKS: System is being carried as a line item in the FY '66 budget; however, funding is to some degree dependent on results of guidance system flight tests at White Sands Missile Range aboard Sergeant missiles; extreme accuracy is a requirement, hence terminal guidance system, which automatically acquires the missile and brings it into the target

Davy Crockett (Army)

TYPE: Surface-to-surface tactical nuclear support weapon

STATUS: Operational

PRIME CONTRACTOR: In-house, Army Weapons Command

FRAME TYPE & CONFIGURATION: Bulbous, 279-mm super caliber projectile fired from either 120-mm or 155-mm recoilless rifle through adapter pistons

PROPULSION TYPE: Solid propellant

GUIDANCE TYPE: Free-flight

PAYLOAD: Sub-kiloton nuclear warhead

PERFORMANCE: Classified

REMARKS: Deployed in Europe; 20 weapons per division; DOD has announced intention of removing weapon system from all operational units as soon as a satisfactory successor can be obtained

ATLAS

ENTAC (MGM-32A) (Army)

TYPE: Antitank missile

STATUS: Operational

PRIME CONTRACTOR: Nord Aviation

FRAME CONFIGURATION: Length, 32 in.; diameter, 5.5 in.; weight, 37 lbs. with launcher, 27 lbs. without launcher

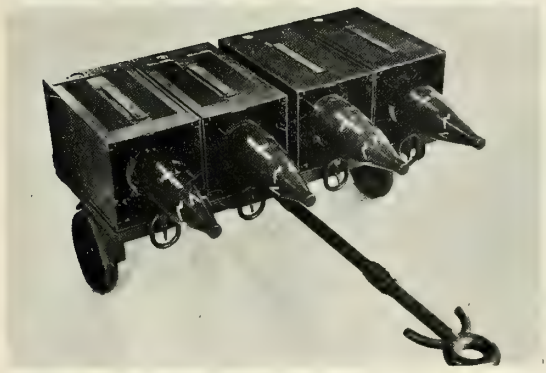
PROPULSION TYPE: Solid

GUIDANCE TYPE: Wire-guided

PAYLOAD: High-explosive shaped charge

PERFORMANCE: 6,600-ft. range; speed about 180 mph

REMARKS: Procurement complete; will be replaced by TOW



Lance (XMGM-52) (Army)

TYPE: Surface-to-surface Division support missile

STATUS: Engineering development

PRIME CONTRACTOR: LTV Michigan Div.

PROPULSION CONTRACTOR: Rocketdyne

PROPULSION TYPE: Prepackaged storable liquid rocket

GUIDANCE CONTRACTOR: Systron-Donner

GUIDANCE TYPE: Modified inertial (Autonet)

PAYLOAD: Primarily an improved (bomblet) high-explosive warhead; nuclear warhead can be used against hard targets; also has chemical capability

PERFORMANCE: Range between 3 and 30 miles; very lightweight system with great mobility

REMARKS: Will replace Honest John and perhaps Little John; initial procurement of missiles and ground equipment for training in FY '65; air- and helicopter-transportable; first flight, March 15, 1965; DOD may re-program FY '66 funds to initiate production if current test program turns out well

Honest John (MGR-1) (Army)

TYPE: Surface-to-surface rocket

STATUS: Operational

PRIME CONTRACTOR: Douglas

FRAME CONTRACTOR: Douglas/Emerson Electric

FRAME TYPE & CONFIGURATION: Length, 24.8 ft.; diameter, 30 in.; weight, 4,500 lbs.

PROPULSION CONTRACTOR: Hercules, main; Thiokol, spin rockets

PROPULSION TYPE: Single-stage solid propellant

GUIDANCE TYPE: Free-flight, spin-stabilized

PAYLOAD: Nuclear or high-explosive warhead

PERFORMANCE: Range, 12 mi.; speed, Mach 1.7

REMARKS: Army inventory requirement filled; to be replaced by Lance; being used by NATO

LASV (Air Force)

TYPE: Surface-to-surface low-altitude supersonic vehicle

STATUS: Powerplant and component development cancelled by DOD; only some research in the chemical engine type being continued

PRIME CONTRACTOR: LTV Astronautics

PROPULSION CONTRACTOR: Atomics International/Lawrence Radiation Laboratory, reactor; Marquardt, overall propulsion; Lockheed, studies of chemical-fueled version

PROPULSION TYPE: Primarily a nuclear-powered, air-breathing ramjet developed under the Pluto program; feasibility proven by Tory reactor tests; shorter range chemical version being studied

GUIDANCE TYPE: Probably all-inertial, with terrain-avoidance radar feature

PAYLOAD: Nuclear warhead

PERFORMANCE: Range, unlimited; speed, over Mach 3

REMARKS: DOD decided not to support a $200 to $500-million flight-test program in July, 1964; Chemical Low Altitude Missile (CLAM) being considered as part of sea-based deterrent study

HONEST JOHN

ENTAC

LANCE

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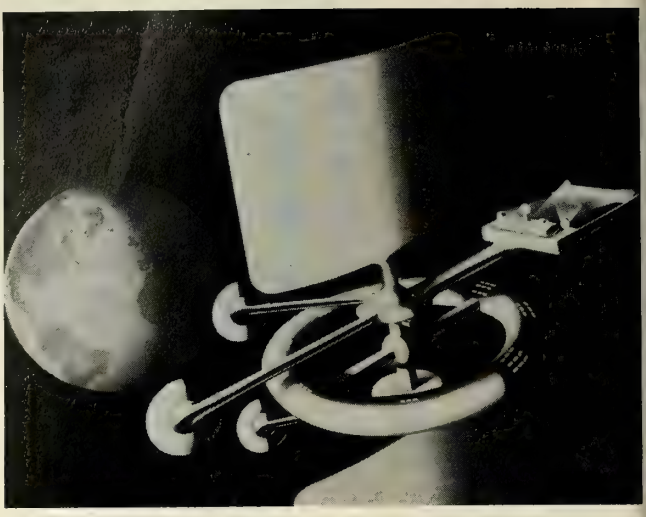

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MISSILE & SPACE DIVISION

GENERAL ELECTRIC

Little John (MGR-3A) (Army)

TYPE: Support of airborne operations

STATUS: Operational

PRIME CONTRACTOR: Emerson Electric Co./Consolidated Western Steel

FRAME TYPE & CONFIGURATION: Steel & aluminum; length, 14.5 ft.; diameter, 12.4 in.; weight, 800 lbs.

PROPULSION CONTRACTOR: Hercules

PROPULSION TYPE: Solid propellant

GUIDANCE TYPE: Free-flight

PAYLOAD: Nuclear or high-explosive warhead

PERFORMANCE: Range, over 10 mi.; speed, supersonic

REMARKS: Supplements medium and heavy artillery in airborne divisions and air-transportable commands; two battalions activated in 1961, each with four launchers; to be replaced by Lance

Mace (MGM-13A) (CGM-13B) (Air Force)

TYPE: Air-breathing

STATUS: Operational

PRIME CONTRACTOR: Martin

FRAME TYPE & CONFIGURATION: Pilotless aircraft type; length, 44 ft.; wingspan, 22.5 ft.; height, 9.5 ft.; weight (A), 14,000 lbs.; (B), 18,000 lbs.

PROPULSION CONTRACTOR: Thiokol/Allison

PROPULSION TYPE: Solid booster rocket/J-33 turbojet

GUIDANCE CONTRACTOR: Goodyear/AC Spark Plug

GUIDANCE TYPE: (A), ATRAN, automatic terrain radar and navigator; (B), inertial warhead

PERFORMANCE: Range: (A), over 650 n. mi.; (B), over 1,200 n. mi.; speed, over 650 mph; ceiling, over 40,000 ft.

REMARKS: A substantially improved version of Matador, which it replaced; A&B version deployed in Europe and B deployed on Okinawa; A fired from mobile launcher; B from a hardened "coffin"-type pad

M72 Rocket Grenade (Army)

TYPE: Anti-tank

STATUS: Operational

PRIME CONTRACTOR: Hesse-Eastern Div., Flightex Fabrics, Inc.

FRAME TYPE & CONFIGURATION: Length, 25 in.; diameter, 3 in.; weight, 4.5 lbs.

PROPULSION TYPE: Solid propellant, which burns out before rocket leaves launch tube

GUIDANCE TYPE: Free-flight, fin-stabilized

PAYLOAD: "Octol" high-explosive warhead

PERFORMANCE: Range, 500 yds.

REMARKS: Carrying tube serves as disposable launcher; replaces rifle grenades and 3.5-in. rocket launcher; formerly called LAW (light anti-tank weapon); useful against tanks, pillboxes and other hard-point targets

Matador (MGM-1C) (Air Force)

TYPE: Air-breathing

STATUS: Operational, phased out of U.S. forces and turned over to allies

PRIME CONTRACTOR: Martin

FRAME TYPE & CONFIGURATION: Pilotless aircraft type; length, 39.6 ft.; height, 9.67 ft.; wingspan, 27.8 ft.; weight, 10,000 lbs.

PROPULSION CONTRACTOR: Thiokol/Allison

PROPULSION TYPE: Solid rocket booster/J-33 turbojet

GUIDANCE CONTRACTOR: Air Force

GUIDANCE TYPE: Dual system including MSQ radar line-of-sight control and "Shanicle," a form of LORAN, using hyperbolic grid system

PAYLOAD: Nuclear warhead, maintained under U.S. control

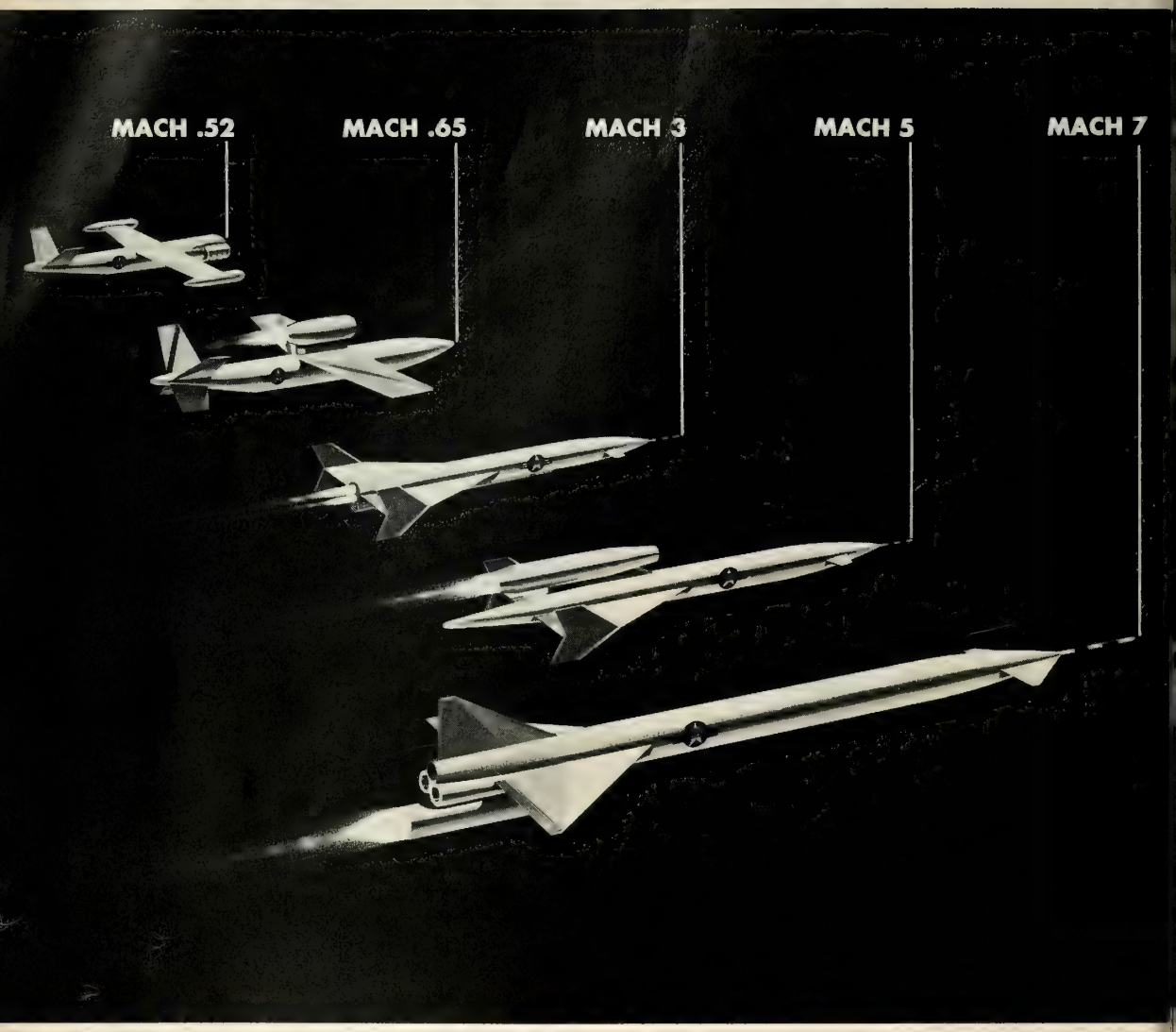
PERFORMANCE: Range, over 600 n. mi.; speed, over 650 mph.; ceiling, over 35,000 ft.

REMARKS: West Germany and Nationalist Chinese using the system

LITTLE JOHN

MACE

Beech "Imaginuity" in missile systems



Now, what's beyond Mach 7?

Beech "Imaginuity" in missile target systems is finding out

How fast will tomorrow's missile target systems need to be? The answer: just as fast as the speediest enemy hardware—jets or missiles—that Free World gunners may have to shoot at. What will it take to provide these advanced missile systems . . . to turn "impossible" requirements into solid reality by the time they are needed?

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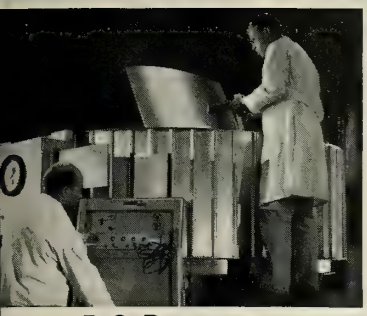
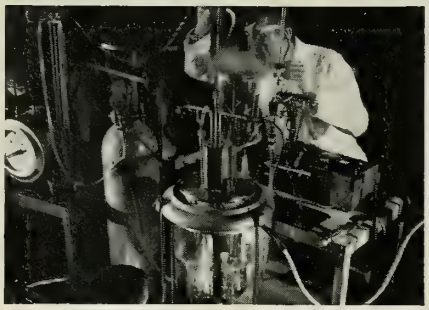
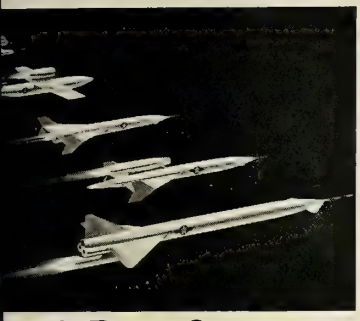


R & D...



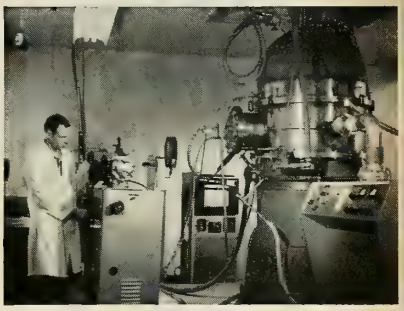
Propulsion...

Auxiliary Power...

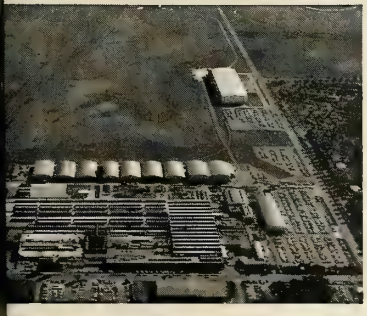


lissile Target Systems

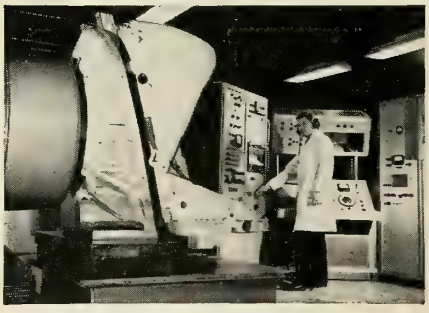
Manufacturing...



Space Simulation...



Facilities...



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MAW (Army)

TYPE: Surface-to-surface anti-tank weapon

STATUS: Program definition

PRIME CONTRACTOR: (Two versions still competing) McDonnell, wire-guided version; Army Missile Command, free rotor gyro version

RANGE: 500-1,500 yds.

GUIDANCE CONTRACTOR: Ford Instrument Co., gyro for Army version

REMARKS: Both designs are line-of-sight weapons; competitive tests in summer of 1965 using a Zuni test vehicle will determine which version will be authorized for full-scale development

Minuteman (LGM-30A, B, F) (Air Force)

TYPE: ICBM

STATUS: A & B operational, F, operational systems development

SYSTEMS CONTRACTOR: TRW Systems Group, systems engineering and technical direction

MAJOR CONTRACTOR: Boeing Co., major contractor and systems integrator; Avco/GE, re-entry vehicles; Sylvania, Minuteman II ground electronics system

FRAME TYPE & CONFIGURATION: Three-stage; length, A, 53.17 ft.; B, 55.9 ft.; F, 59.8 ft.; diameter at interstage junction, 6.2 ft.; weight, 65,000 lbs.

PROPULSION CONTRACTOR: Thiokol/Aerojet-General/Hercules, respectively, by stages

PROPULSION TYPE: Solid propellant

GUIDANCE CONTRACTOR: North American Autonetics

GUIDANCE TYPE: All-inertial

PAYLOAD: Nuclear warhead

PERFORMANCE: Range, 6,000-7,000 n. mi.; speed, over 15,000 mph; apogee, 700 mi.; reaction time, 32 sec.; target selection time, less than 10 sec.; yield, about one megaton

REMARKS: Force size now authorized 1,000 missiles, all 800 planned Minuteman I missiles were operational June 30, 1965, completing A & B programs; Malmstrom AFB, Mont., only base with range-deficient A version; B missiles deployed at Malmstrom, Ellsworth, S.D., Whiteman, Mo., Minot, N.D., Grand Forks, N.D., and Warren AFB, Wyo.; launched from underground silos; F version with improved second stage and guidance can be launched by aerial command post signal as well as from ground posts; the F model (Minuteman II) will eventually replace earlier models in all silos

MINUTEMAN

Pershing (Army)

TYPE: Two-stage ballistic missile

STATUS: Operational

PRIME CONTRACTOR: Martin/Orlando

FRAME CONFIGURATION: Length, 35 ft.; diameter, 40 in.; weight, 10,000 lbs.

PROPULSION CONTRACTOR: Thiokol

PROPULSION TYPE: Two-stage solid propellant

GUIDANCE CONTRACTOR: Eclipse-Pioneer Div., Bendix

GUIDANCE TYPE: Inertial

PAYLOAD: Nuclear warhead

GROUND EQUIPMENT CONTRACTORS: FMC Corp., XM-474 tracked vehicles; Universal Match Corp., transporter/erector/launcher; Collins Radio, communications

PERFORMANCE: Range, 100-400 n. mi.; speed, supersonic

REMARKS: Has replaced all Redstone units; completely mobile; firing unit is carried on four tracked vehicles; consideration being given to increasing the number of launchers per battalion; West Germany procuring

Polaris (UGM-27 A, B, C) (Navy)

TYPE: Surface-to-surface strategic missile fired from submerged submarines

STATUS: All three versions operational

PRIME CONTRACTOR: Lockheed

FRAME TYPE & CONFIGURATION: A-1 length, 28 ft.; diameter 4-5 ft.; weight, 28,000 lbs.; A-2 & A-3 length, 30.5 ft., diameter, 4.5 ft.; weight, 30,000 lbs.

PROPULSION CONTRACTOR: Aerojet-General/Hercules

PROPULSION TYPE: Solid

GUIDANCE CONTRACTOR: GE/MIT/Hughes

GUIDANCE TYPE: All-inertial

PAYLOAD: Nuclear warhead, about one megaton

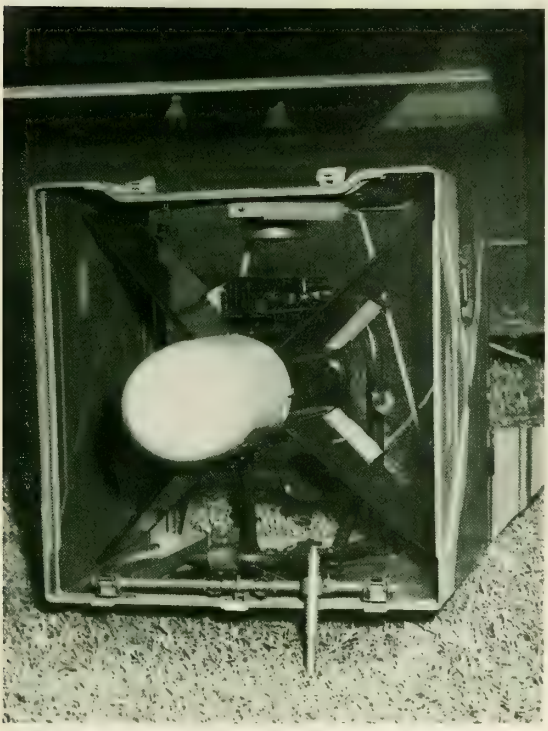
EQUIPMENT CONTRACTORS: Northrop Nortronics, checkout; Westinghouse, launch equipment, Vitro, systems engineering coordination and training; Systron-Donner, ignition programming

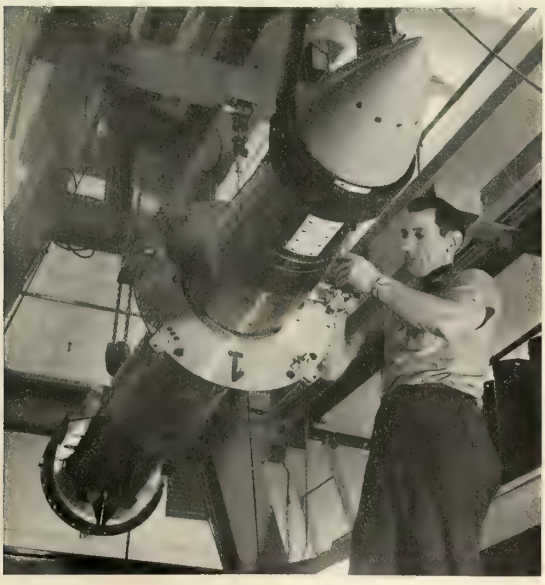
PERFORMANCE: Range A-1, 1,200 n. mi.; A-2, 1,500 n. mi.; A-3, 2,500 n. mi.; speed, about 8,000 mph

REMARKS: Twenty-six submarines, each with 16 missiles operational with A-1, A-2 and A-3; total authorized fleet ballistic missile submarine program is 41 ships with all to be operational by the end of FY '67; subs now deployed in Atlantic, Mediterranean and Pacific; British to buy missiles from U.S. for Royal Navy; Poseidon (3-C, formerly B-3) version with as much as a 50% increase in range/payload now in project definition

PERSHING

POLARIS





Sergeant (MGM-29A) (Army)

TYPE: Single-stage ballistic missile

STATUS: Operational

PRIME CONTRACTOR: Sperry Utah Co.

FRAME CONFIGURATION: Length, 34.5 ft.; diameter, 31 in.; weight, 10,000 lbs.

PROPULSION CONTRACTOR: Thiokol

PROPULSION TYPE: Single-stage solid-propellant, employs drag brakes to control range

GUIDANCE CONTRACTOR: Sperry

GUIDANCE TYPE: Inertial

PAYLOAD: Nuclear warhead

GROUND EQUIPMENT CONTRACTORS: Fruehauf, transport vehicles; AMF, erector/launcher; AiResearch, gas turbine generators

PERFORMANCE: Range 25-75 n. mi.; speed, supersonic

REMARKS: All Army tactical units fully equipped with this missile, replacing Corporal; Germany buying

SS-10 (Army)

TYPE: Surface-to-surface anti-tank missile

STATUS: Operational, being replaced by ENTAC

PRIME CONTRACTOR: Nord Aviation, prime; GE, U.S. licensee

FRAME TYPE & CONFIGURATION: Length, 34 in.; diameter, 6 in.; wingspan, 30 in.; weight, 33 lbs.; cruciform wings

PROPULSION TYPE: Solid propellant

GUIDANCE TYPE: Wire-guided

PAYLOAD: High-explosive shaped charge

PERFORMANCE: Range, 1,600 yds.; speed, 180 mph

REMARKS: In service with U.S. forces in Europe; being replaced with ENTAC

Shillelagh (MGM-51A) (Army)

TYPE: Tactical guided missile for infantry support

STATUS: Operational evaluation

PRIME CONTRACTOR: Philco Aeronutronic

FRAME CONFIGURATION: Diameter, 152 mm; weight, 40 lbs.

PROPULSION CONTRACTOR: Picatinny Arsenal/Amoco Chemicals Corp.; Clary Corp., gyroscopes; Norris Thermador, motor cases

PROPULSION TYPE: Solid propellant

GUIDANCE CONTRACTOR: Aeronutronic

GUIDANCE TYPE: Command

PAYLOAD: High-explosive warhead

GROUND EQUIPMENT CONTRACTORS: Cadillac Motor Div., General Motors, supplies the General Sheridan armored reconnaissance, airborne assault vehicle armed with Shillelagh; Chrysler supplies M-60 tank, which is also to be armed with Shillelagh in connection with development of a new low-silhouette tank turret

PERFORMANCE: Classified

REMARKS: To be used against tanks, pillboxes and other hardpoint targets; being tested at White Sands Missile Range; will use multi-system test equipment; Army also investigating use of missile from airborne platforms

Subroc (UUM-44A) (Navy)

TYPE: Anti-submarine rocket

STATUS: Operational evaluation completed

PRIME CONTRACTOR: Goodyear Aerospace

FRAME CONFIGURATION: Length, 21 ft.; diameter, 21 in.; weight, 4,000 lbs.

PROPULSION CONTRACTOR: Thiokol

PROPULSION TYPE: Solid rocket

GUIDANCE TYPE: Inertial

GUIDANCE CONTRACTOR: General Precision/Aerospace

PAYLOAD: Nuclear or high-explosive warhead

EQUIPMENT CONTRACTORS: General Precision/Librascope Div., fire control; Garrett Corp., AiResearch Div., auxiliary power.

PERFORMANCE: Range, 25-30 mi.

REMARKS: Fired from submarine torpedo tubes, leaves water in flight, re-enters water and seeks enemy submarine; first system was aboard submarine Thresher, and loss of that vessel set evaluation program back; expected to join fleet in operational status in 1965

SERGEANT

SS-10

SUBROC

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Titan II (LGM-25C) (Air Force)

TYPE: ICBM

STATUS: Operational

PRIME CONTRACTOR: Martin Denver, Frame; TRW Systems, systems engineering and technical direction

FRAME TYPE & CONFIGURATION: Length, 103 ft.; diameter, 10 ft.; weight, 330,000 lbs.

PROPULSION CONTRACTOR: Aerojet-General

PROPULSION TYPE: Liquid propellants, nitrogen tetroxide and a 50/50 mixture of hydrazine and UDMH; two engines first stage, one engine second stage; 430,000 lbs. thrust first stage; 100,000 lbs. thrust second stage

GUIDANCE CONTRACTOR: AC Spark Plug

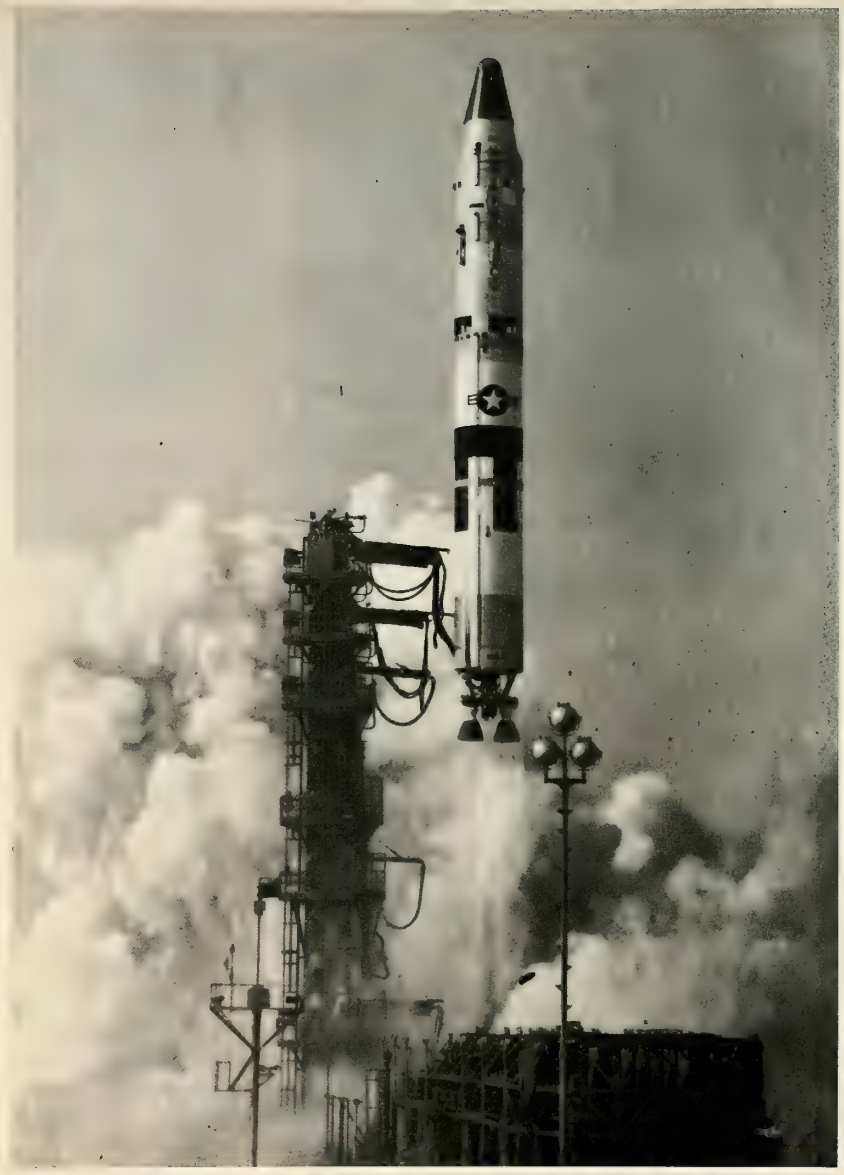
GUIDANCE TYPE: Inertial

PAYLOAD: Nuclear warhead; about 20 megatons; re-entry vehicle, General Electric

GROUND EQUIPMENT CONTRACTOR: Martin Co.

PERFORMANCE: Range, over 6,300 n. mi.; speed, over 16,000 mph

REMARKS: Greatest payload & range of any U.S. ICBM; carries most sophisticated and effective penetration aids of any U.S. missile; constitutes basic core vehicle for Titan III; all squadrons operational at 3 bases (54 missiles total); adapted for use as Gemini space booster



TOW (Army)

TYPE: Anti-tank missile

STATUS: Engineering development

PRIME CONTRACTOR: Hughes

FRAME TYPE & CONFIGURATION: Tube-launched, optically-tracked, wire-guided; system total weight, 160 lbs.

PROPULSION TYPE: 2-stage solid propellant—one charge to eject round from launch tube before second motor ignites

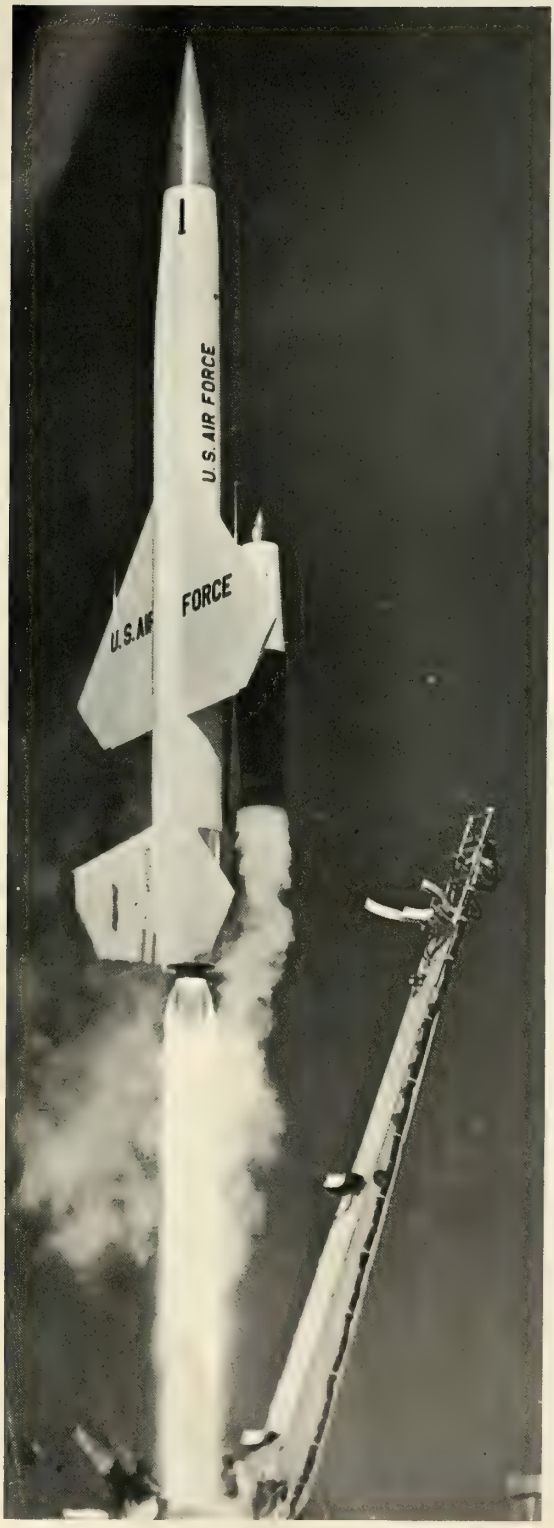
GUIDANCE TYPE: Wire-guided through a link in the optical sight

PAYLOAD: High-explosive warhead

REMARKS: Replacement for ENTAC; bore-sighted firings being conducted at Army Missile Command

TITAN II

TOW



BOMARC

Advanced Surface Missile System (Navy)

TYPE: Surface-to-air for fleet air defense

STATUS: Program definition

PRIME CONTRACTOR: Teams for competition are: Westinghouse/Bendix-Mishawaka/NAA-Columbus; Boeing/TRW Systems Group/Collins Radio/Litton/Bendix Radio Div.; Sperry/General Dynamics-Pomona/Univac; Hughes/Douglas-Charlotte/Northern Ordnance; RCA/Martin; and GE/Douglas Missiles and Space Systems Div.; some of competition given contract extensions to continue study

CONFIGURATION: Missile will combine components of Terrier and Tartar systems into a single standardized weapon; must be compatible with existing shipboard launch systems

PROPULSION: Solid

PAYLOAD: High-explosive warhead

REMARKS: Development expected to begin in FY '65; like the cancelled Typhon, this system still more cumbersome than Navy would like for installation in smaller ships of the fleet; $12 million requested in FY '66 to complete PDP

Anti-Satellite Weapon (Air Force)

TYPE: Ground-launched missile for destruction of hostile spacecraft

STATUS: Described by White House as "operational"

PRIME CONTRACTOR: None announced; Air Force Space Systems Div. is managing program, with Navy's Bureau of Yards and Docks doing construction work at Johnston Island

CONFIGURATION: Thor and Thrust-Augmented Thor will be used as booster, with Agena D upper stage; final maneuvering to the target will be done by radar-homing third stage

SCHEDULE: Flight tests expected as early as late 1965 or early 1966

REMARKS: System being developed as "insurance" against any Soviet space threat that may appear; safeguard guarantees of the Nuclear Test Ban Treaty are being used as a cover for the program

Bomarc (CIM-10B) (Air Force)

TYPE: Surface-to-air

STATUS: Operational

PRIME CONTRACTOR: Boeing

FRAME TYPE & CONFIGURATION: Length, 46.9 ft. (B, 45 ft.); wingspan, 18.2 ft.; diameter, 35 in.; weight, 16,000 lbs.

PROPULSION CONTRACTOR: Thiokol/Marquardt

PROPULSION TYPE: Solid rocket booster, ramjet sustainer

GUIDANCE CONTRACTOR: IBM/Westinghouse/General Precision

GUIDANCE TYPE: Command via SAGE system, then active radar homing to target

PAYLOAD: Nuclear warhead

GROUND EQUIPMENT CONTRACTORS: FMC Corp., launcher/erector

PERFORMANCE: Range, over 200 n. mi. (B, 400 n. mi.); speed, Mach 2.5; ceiling, over 68,000 ft. (B, over 90,000 ft.); B also has low-altitude capability

REMARKS: 224 Bomarc B's operational at eight bases; all A missiles have been phased out; B missiles are distributed among six U.S. and two Canadian sites

Chaparral (Army)

TYPE: Surface-to-air missile

STATUS: Development

PRIME CONTRACTOR: Philco Aeronutronic

PHYSICAL CHARACTERISTICS: A surface-to-air adaptation of the air-to-air Sidewinder missile, to be mounted on Army tracked vehicles in a 4- or 6-missile configuration; for other data, see Sidewinder

REMARKS: Chaparral being developed as an interim solution to Army's forward-area air defense problems

Hawk (MIM-23A) (Army)

TYPE: Surface-to-air defense missile against low-flying planes

STATUS: Operational

PRIME CONTRACTOR: Raytheon

FRAME CONTRACTOR: Northrop Nortronics, system contractor

FRAME TYPE & CONFIGURATION: Length, 16.8 ft.; diameter, 14 in.; weight, 1,275 lbs.

PROPULSION CONTRACTOR: Aerojet-General

PROPULSION TYPE: Solid propellant, dual stage

GUIDANCE CONTRACTOR: Raytheon

GUIDANCE TYPE: Semi-active radar homing

PAYLOAD: High-explosive warhead

GROUND EQUIPMENT CONTRACTORS: Mechanical GSE, Northrop Nortronics; guidance GSE, Raytheon; test equipment, RCA; launcher/loader/carrier, FMC Corp.; radar pedestals, Bendix; radar antennas, Goodyear

PERFORMANCE: Range, 22 mi.; speed, supersonic; ceiling, 100 to 45,000 ft.

REMARKS: Procurement complete; deployed in Europe, Panama, Okinawa, and the U.S.; bought by Sweden and Israel; advanced Hawk being developed for anti-tactical-missile use; has intercepted Corporal, Honest John and Little John rockets in flight; a more mobile, track-mounted "division weapon" version of Hawk is being studied; $44.6 million earmarked in FY '65 and $9.4 million requested in FY '66 for Hawk improvement; program spurred by difficulties with Mauler

HIBEX (ARPA/ Army)

TYPE: Experimental program in high-energy propellants

STATUS: Development

PRIME CONTRACTOR: Boeing

CONFIGURATION: Classified

PERFORMANCE: Classified

PROPULSION CONTRACTOR: Hercules, double base; Aerojet-General, composite

PROPULSION: High-energy solid

REMARKS: Army Missile Command managing program for ARPA; accelerations of 800-1,000 g's goal; first successful flight test, February, 1965, at WSMR; studies funded for guided second stage

Mauler (XMIM-46A) (Army)

TYPE: Surface-to-air anti-aircraft, anti-missile system

STATUS: Feasibility validation studies completed

PRIME CONTRACTOR: General Dynamics/Pomona

FRAME CONTRACTOR: GD/Pomona

FRAME TYPE & CONFIGURATION: Dart-shaped; length, about 6 ft.; diameter, 5 in.; weight, 120 lbs.; each firing unit has 9 missiles, 3 rows of 3 missiles each

PROPULSION CONTRACTOR: Lockheed

PROPULSION TYPE: Single-stage solid propellant

GUIDANCE CONTRACTOR: Hughes, guidance; deHavilland of Canada, infrared acquisition system; Raytheon, radar; Burroughs, computer

GUIDANCE TYPE: Sky-sweeping acquisition radar, target-illuminating pinpoint radar, then IR-homing for terminal phase (optional)

PAYLOAD: High-explosive warhead

GROUND EQUIPMENT CONTRACTORS: FMC Corp., XM-546 self-propelled tracked vehicle

PERFORMANCE: Designed to rapidly engage and destroy enemy supersonic aircraft and rockets in the Honest John/Little John class; must be able to move with front-line troops

REMARKS: In final stages of top-level Army evaluation after feasibility study; Army user commands, R&D chiefs deciding whether to continue program; program termination considered likely; fully air-transportable; weapon pod contains all fire control and launch equipment as well as 9 missiles; pod can be removed for permanent emplacement if desired; system has three crew members, but can operate with two

HAWK

MAULER

NIKE-HERCULES

SPRINT

Nike-Hercules (MIM-14B) (Army)

TYPE: Surface-to-air air defense missile

STATUS: Operational

PRIME CONTRACTOR: Western Electric

FRAME CONTRACTOR: Douglas

FRAME TYPE & CONFIGURATION: Length, 41 ft.; diameter, 31.5 in.; weight, 10,000 lbs.

PROPULSION CONTRACTOR: Thiokol

PROPULSION TYPE: Two-stage solid propellant

GUIDANCE CONTRACTOR: Western Electric

GUIDANCE TYPE: Command; system uses low-power acquisition, high-power acquisition, target-tracking, and missile-tracking radars in conjunction with electronic data-processing gear

PAYLOAD: Nuclear warhead

GROUND EQUIPMENT CONTRACTORS: Launchers, Consolidated Western Steel; transport vehicles, Fruehauf; ground guidance, Western Electric

PERFORMANCE: Range, over 75 n. mi.; ceiling, 100,000 ft.; speed, over Mach 3

REMARKS: Over 80 batteries deployed in U.S.; 10 batteries deployed overseas in Europe and on Taiwan; being equipped with Hipar, a high-power acquisition radar, for anti-tactical ballistic missile capabilities; plan to relocate some Nike-Hercules batteries under consideration by DOD

Sprint (Nike-X System) (Army)

TYPE: Surface-to-air A-ICBM/SLBM missile

STATUS: Development

PRIME CONTRACTOR: Martin

FRAME TYPE & CONFIGURATION: Smaller than Nike-Zeus; two-stage, length, 27 ft.; diameter at base, 4.5 ft.; missile is conical

PROPULSION CONTRACTOR: Hercules/Lockheed

PROPULSION TYPE: Solid propellant; extremely high acceleration

GUIDANCE CONTRACTOR: Western Electric

GUIDANCE TYPE: Command; will be mixed with Zeus missiles in batteries controlled by multi-function array radar (MAR) and missile site radar (MSR); components must withstand tremendous g forces

PAYLOAD: Nuclear warhead

PERFORMANCE: Range, classified; speed, classified; acceleration, extremely high

REMARKS: Will engage enemy ICBM's at relatively low altitudes to allow the atmosphere to strip away decoys and permit clearer discrimination by defensive radar; missile will be "popped" from silo before ignition and flight to target

Nike-X (Army)

TYPE: Dual-missile (Zeus and Sprint) A-ICBM/SLBM system

STATUS: Development

PRIME CONTRACTOR: Western Electric; Bell Laboratories, design and development

FRAME TYPE & CONFIGURATION: Douglas, Zeus frame; Martin-Orlando, Sprint frame; Sprint is smaller than Zeus

OTHER CONTRACTORS: Thiokol, Zeus propulsion; Hercules/Lockheed, Sprint propulsion; Bell Telephone Labs, system design and development; Sylvania, MAR-1; GE-MAR; Raytheon, MAR & MSR; Douglas, Zeus missile; Martin Orlando, Sprint missile

PROPULSION TYPE: Solid propellants for three Zeus stages, two Sprint stages

GUIDANCE CONTRACTOR: Western Electric

GUIDANCE TYPE: Command; will use MAR (multi-function array radar) instead of three separate radars for target acquisition, tracking and discrimination; missile site radar (MSR) will track and control more than one defensive missile at a time

PAYLOAD: Nuclear warheads for both Zeus and Sprint

PERFORMANCE: Zeus—range, over 200 n. mi.; speed, over Mach 4; Sprint—shorter in range than Zeus but with acceleration well in excess of 100 g

REMARKS: Nike-X uses advanced MAR and Sprint missile to greatly enhance capabilities against ICBM's of 1970's; each Nike-X battery will contain mix of Zeus and Sprint missiles to allow flexibility in engaging enemy warheads at long (Zeus) or short (Sprint) ranges; system can acquire, track and engage a number of targets simultaneously, firing either missile from mix available; new computers will allow greater speed and data-handling capacity; MAR under test at White Sands Missile Range for more than a year; Sprint has been successfully test-flown at WSMR; Zeus has already intercepted target ICBM's and satellites

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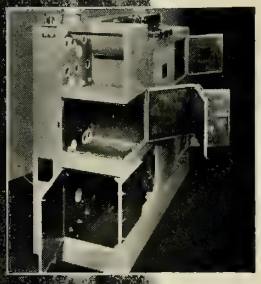

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Zeus (Nike-X System) (Army)

TYPE: Surface-to-air A-ICBM

STATUS: Advanced development as part of Nike-X

PRIME CONTRACTOR: Western Electric

FRAME CONTRACTOR: Douglas

FRAME TYPE & CONFIGURATION: Length, 48.3 ft.; diameter, (sustainer) 36 in.; fin span, 10 ft.; launch weight, 22,800 lbs.

PROPULSION CONTRACTOR: Thiokol

PROPULSION TYPE: Three-stage solid propellant, with "jet-head" system for manuevering in space; acceleration very high

GUIDANCE CONTRACTOR: Western Electric

GUIDANCE TYPE: Command; system uses MAR and MSR acquisition radar in conjunction with ultra-high-speed electronic data-processing gear

PAYLOAD: Nuclear warhead

PERFORMANCE: Slant range, about 200 n. mi.; speed over Mach 4

REMARKS: Missile has become part of the Nike-X missile "mix;" highly successful intercept program has been essentially completed; third-stage components have been repackaged and a more powerful booster added

Redeye (MIM-43) (Army and Marines)

TYPE: Shoulder-fired anti-aircraft missile

STATUS: Production

PRIME CONTRACTOR: General Dynamics/Pomona

FRAME TYPE & CONFIGURATION: Bazooka-type, wingless cylindrical weapon; length, 48 in.; diameter, 2.75 in.; weight, 28 lbs.

PROPULSION CONTRACTOR: Atlantic Research

PROPULSION TYPE: Dual-stage solid propellant

GUIDANCE CONTRACTOR: Philco/General Dynamics/Pomona

GUIDANCE TYPE: Infrared

PAYLOAD: High-explosive warhead

PERFORMANCE: Range, classified; speed, supersonic

REMARKS: First groups of Army and Marine Corps personnel to use the weapon completed training at Fort Sill, Okla., in late 1964

SAM-D (Army)

TYPE: Surface-to-air air defense missile system

STATUS: Pre-program definition

PRIME CONTRACTOR: Hughes teamed with Douglas, and FMC and RCA with Beech, selected to do component development work on the system during the coming year

CONFIGURATION: System intended to provide defense for field army against 1970 version tactical ballistic missiles and aircraft; similar to Mauler, entire system was to have been mounted on a single vehicle, but Army sources say only that it has to be mounted on the "minimum" number of vehicles

REMARKS: Expense is one reason for delay in development; also target acquisition and missile guidance are pushing state of the art; system, or one like it, would be required to protect Nike-X from air-breathing cruise missile threat; formerly designated AADS-70

Seaspar (Navy)

TYPE: Surface-to-air, ship-launched

STATUS: Pre-development

PRIME CONTRACTOR: Navy Bureau of Weapons

RANGE: 5 to 8 n. mi.

CONFIGURATION: Length, 12 ft., diameter, 8 inches, weight 380 lbs. (for others, see Sparrow)

REMARKS: A shipboard-launched adaptation of the air-to-air missile being considered by Navy as a point-defense weapon for deployment on small or austerely equipped vessels; would use a modified 3-in. gun mount as launcher

Standard Missile (Navy)

TYPE: Advanced short- and medium-range surface-to-air missile

STATUS: Development

PRIME CONTRACTOR: General Dynamics/Pomona

RANGE: One version (scheduled to replace Tartar) in excess of 10 n. mi.; second version (scheduled to replace Terrier) greater than 30 n. mi.

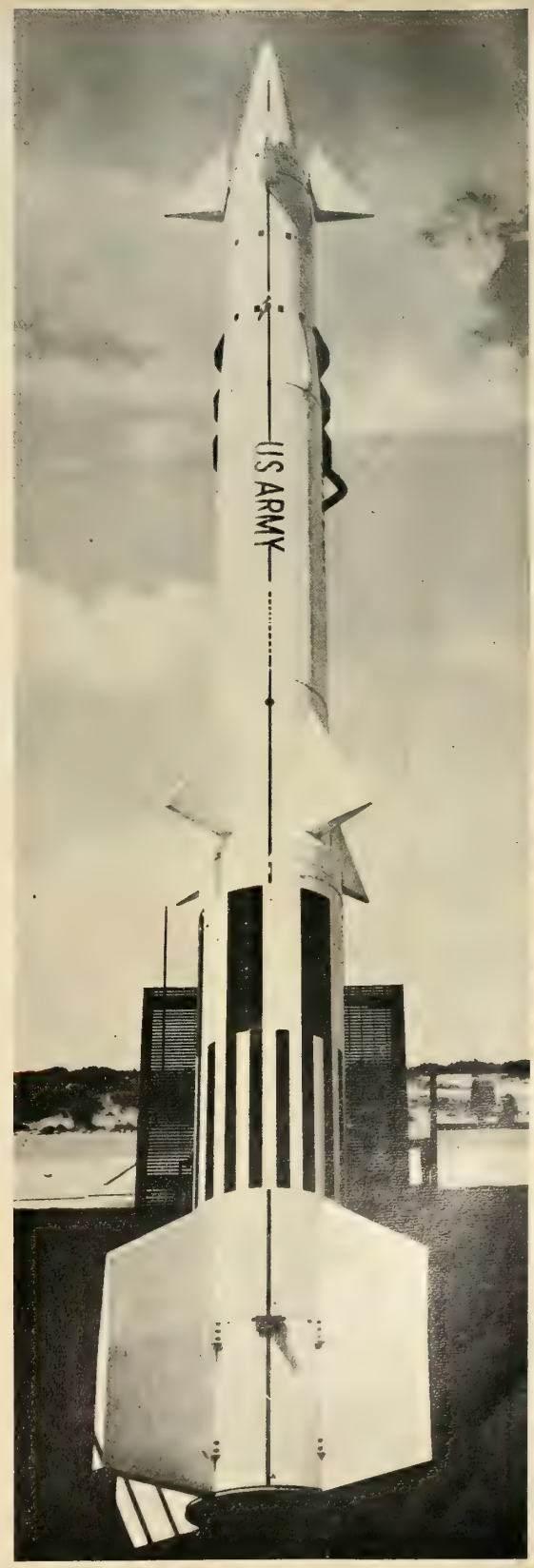
CONFIGURATION: Both missiles about 15 ft. long, 1 ft. diameter

PROPULSION: One version (scheduled to replace Tartar) dual-thrust solid propellant rocket; second version (scheduled to replace Terrrier) solid propellant booster and sustainer rockets

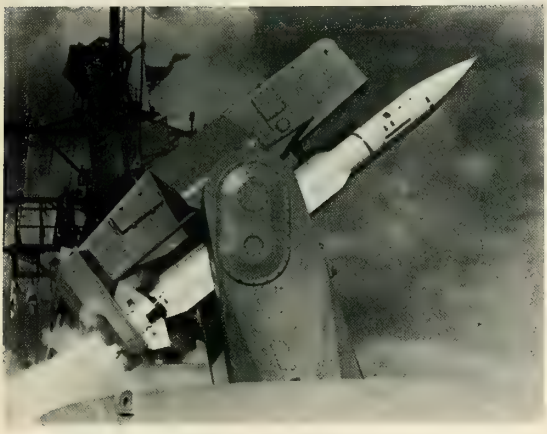
LAUNCHING SYSTEMS: Tartar/Terrier systems with modifications toward more standardization of the launch equipment

WARHEAD: High explosive, same as Terrier and Tartar

REMARKS: To replace Tartar and Terrier



NIKE-ZEUS



Tactical Probe (Navy)

TYPE: Surface-to-air probe

MISSION: To gather meteorological and electronic warfare data and provide emergency communications

STATUS: Program definition

PRIME CONTRACTOR: None; Bendix and Astronautics Div. of Ling-Temco-Vought are thought to be the front runners in the program; one of the two will be selected for the $40-million development; Bendix has been awarded a $249,000 study contract

CONFIGURATION: Consists of multiple, interchangeable payloads for each mission; launched by Terrier or Talos from present shipboard installations; has a high-impulse second stage

PERFORMANCE: Range 50-300 n. mi. from launching ship; descent would be by parachute in which 15 min. of useful data could be telemetered back to the ship

REMARKS: Navy has been told by DOD to restudy its requirement to come up with a cheaper program

Talos (RIM-8E) (Navy)

TYPE: Surface-to-air cruise missile for long-range fleet air defense

STATUS: Operational

PRIME CONTRACTOR: Bendix Mishawaka, assembly and test; Vitro, systems engineering

FRAME TYPE & CONFIGURATION: Two stages; overall length, about 30 ft.; diameter about 30 in.; weight 7,000 lbs., 4,000 of which is 10-ft.-long booster

PROPULSION CONTRACTOR: Allegany Ballistics Laboratory, propulsion (booster design), development and pilot production; Naval Propellant plant, booster loading

PROPULSION TYPE: Solid propellant booster/ramjet sustainer

GUIDANCE CONTRACTOR: Bendix Mishawaka

GUIDANCE TYPE: Dual; beam-riding to target area, then semi-active homing in terminal phase

PAYLOAD: Nuclear or high-explosive warhead

EQUIPMENT CONTRACTORS: Naval Weapons Plant, launchers; McDonnell, missile frame; Fairchild Stratos, guidance metal parts module

PERFORMANCE: Range, over 65 n. mi.; speed, over Mach 2.5; ceiling, over 90,000 ft.

REMARKS: Operational singly aboard three CLG type cruisers with Tartar, three CG cruisers, and aboard the Long Beach (CGN) with Terrier; Talos is not currently slated for any new construction; included in Navy's "get well" program to boost kill rate

TALOS

TARTAR

TERRIER

Tartar (RIM-24B) (Navy)

TYPE: Surface-to-air missile for fleet air defense

STATUS: Operational

PRIME CONTRACTOR: General Dynamics/Pomona, assembly and test; Vitro, systems coordination engineering

FRAME TYPE & CONFIGURATION: Single-stage, length, 15-ft.; diameter, under 18 in.; weight, about 1,500 lbs.

PROPULSION CONTRACTOR: Aerojet-General

PROPULSION TYPE: Dual-burn solid propellant

GUIDANCE CONTRACTOR: General Dynamics/Pomona; target detection device, Philco and Sperry Farragut

GUIDANCE TYPE: Semi-active homing

PAYLOAD: High-explosive warhead

PERFORMANCE: Range, over 10 n. mi.; speed, Mach 2

REMARKS: Deployed aboard 23 DDG type destroyers and 3 CG type cruisers equipped with Talos; 12 Tartar ships and one Talos/Tartar ship under construction/conversion; also slated for installation aboard 6 DDG type destroyers in foreign navies (3 German and 3 Australian); Tartar also scheduled for deployment on new aircraft carrier Kennedy (CVA-67); Navy conducting "get well" program on Tartar to increase its kill rate; will be combined with Terrier in standard missile

Terrier (RIM-2E) (Navy)

TYPE: Surface-to-air missile for fleet air defense

STATUS: Operational

PRIME CONTRACTOR: General Dynamics/Pomona, assembly and test; Vitro, systems coordination engineering

FRAME TYPE & CONFIGURATION: Two-stage; overall length, 27 ft., with 12-ft. booster; diameter, about 1 ft.; weight, about 3,000 lbs.

PROPULSION CONTRACTOR: Naval Propellant Plant and Atlantic Research, booster and sustainer loading

PROPULSION TYPE: Two-stage; solid-propellant booster and sustainer

GUIDANCE CONTRACTOR: General Dynamics/Pomona, guidance section

GUIDANCE TYPE: Semi-active radar beam-riding homing

PAYLOAD: High-explosive warhead

PERFORMANCE: Range, over 10 n. mi.; speed, Mach 2.5; ceiling, over 65,000 ft.

REMARKS: Navy "get well" program continuing; system will be combined with Tartar in standardized missile

Falcon (AIM-4A C, E, F AIM-26A/ AIM-47A) (Air Force)

TYPE: Family of air-to-air missiles

STATUS: Operational

PRIME CONTRACTOR: Hughes

FRAME TYPE & CONFIGURATION: Single stage; length, 6.5 ft.; diameter, 6 in.; weight, over 100 lbs. (for all except AIM-26A); AIM-26A length, about 7 ft.; diameter, 11 in.; weight, over 200 lbs.; fin span, 20 in.

PROPULSION CONTRACTOR: Thiokol for all except AIM-47A; Lockheed Propulsion for AIM-47A

PROPULSION TYPE: Solid propellant; thrust varies with missile, but is about 6,000 lbs.

GUIDANCE CONTRACTOR: Hughes

GUIDANCE TYPE: Varies with missile; active radar homing/infrared homing/hybrid IR-radar homing

PAYLOAD: Nuclear warhead on AIM-26A; high-explosive warhead on others

PERFORMANCE: Range, over 5 n.mi.; speed, supersonic; ceiling, above 50,000 ft.

REMARKS: Missiles formerly designated GAR-1, 2, 3 and 4 now AIM-4; GAR-11 now AIM-26A; GAR-9 now AIM-47A; series deployed with NORAD on fighter interceptors; procurement for most versions completed; AIM-47A developed for use on YF-12A aircraft

Genie (AIR-2A) (Air Force)

TYPE: Air-to-air missile

STATUS: Operational

PRIME CONTRACTOR: Douglas

FRAME TYPE & CONFIGURATION: Length, 9.5 ft.; diameter, 17.35 in.; weight, 800 lbs.

PROPULSION CONTRACTOR: Aerojet-General

PROPULSION TYPE: Solid propellant

GUIDANCE TYPE: Free flight

PAYLOAD: Nuclear warhead with proximity fuzing

PERFORMANCE: Range, over 6 n.mi.; speed, about Mach 3; ceiling, above 50,000 ft.

REMARKS: Procurement complete; provides area defense against attacking bombers; carried by NORAD fighter interceptors; launcher being developed by McDonnell for adaptation to F-4 aircraft

Phoenix (AIM-54A) (Navy)

TYPE: Air-to-air missile for F-111B (TFX) aircraft

STATUS: Development

PRIME CONTRACTOR: Hughes

PROPULSION TYPE: Single-stage, solid propellant

PROPULSION CONTRACTOR: Rocketdyne

GUIDANCE CONTRACTOR: Hughes

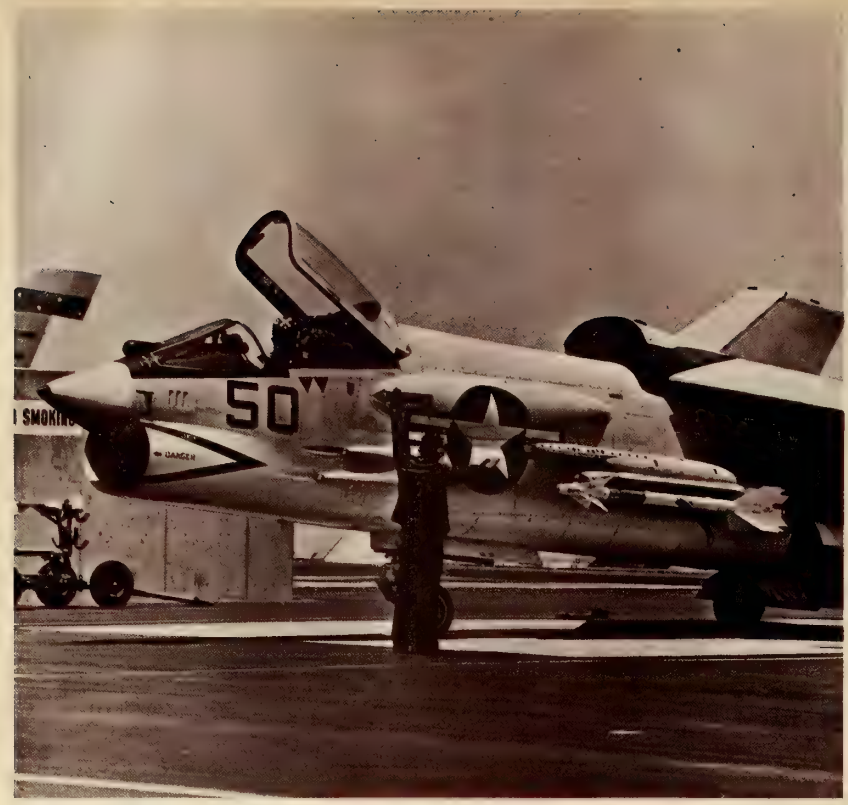
PAYLOAD: High-explosive warhead

PERFORMANCE: Details classified, but extensive range and altitude capabilities required; performs in both active and semi-active mode, has multishot capability; first flight test planned in March, 1966; $71 million requested in FY'66; Sparrow missile may be used as short-range complement

REMARKS: Has some features similar to cancelled Eagle missile, which was to be used with Missileer long-duration aircraft; each Navy F-111 can carry six missiles on wing hard points, others in weapons bay

FALCON

GENIE



Sidewinder IC (AIM-9D) (Navy, Air Force)

TYPE: Air-to-air missile

STATUS: Operational

PRIME CONTRACTOR: Philco/GE; technical direction, Naval Ordnance Test Station

FRAME TYPE & CONFIGURATION: Length, 9 ft.; diameter 5 in.; weight, about 155 lbs.

PROPULSION CONTRACTOR: Naval Propellant Plant, Rocketdyne

PROPULSION TYPE: Solid propellant

GUIDANCE CONTRACTOR: Philco/GE; Raytheon on IC

GUIDANCE TYPE: Infrared homing; an interchangeable semiactive radar homing device is also available

PAYLOAD: High-explosive warhead

PERFORMANCE: Range, over 2 n.mi.; speed, supersonic; ceiling, over 50,000 ft.

REMARKS: In use by Navy, Air Force; NATO-built version under test

Sparrow III-6B (AIM-7E) (Navy)

TYPE: Air-to-air missile

STATUS: Operational

PRIME CONTRACTOR: Raytheon

FRAME TYPE & CONFIGURATION: Length, about 12 ft.; diameter, 8 in.; weight, about 350 lbs.

PROPULSION CONTRACTOR: Aerojet-General, Rocketdyne

PROPULSION TYPE: Solid propellant

GUIDANCE CONTRACTOR: Raytheon

GUIDANCE TYPE: Semiactive CW homing

PAYLOAD: High-explosive warhead

PERFORMANCE: Range, 8 n.mi.; speed, Mach 3; ceiling, over 50,000 ft.

REMARKS: Supersonic all-weather 360° attack capability; deployed on carrier aircraft; prime armament on F4H interceptors; Sparrow III and IIIA in use; being studied for adaptation to ships in a surface-to-air mode (see: Seaspar); may be used with Phoenix as air-to-air missile for F-111B

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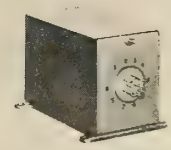

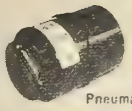

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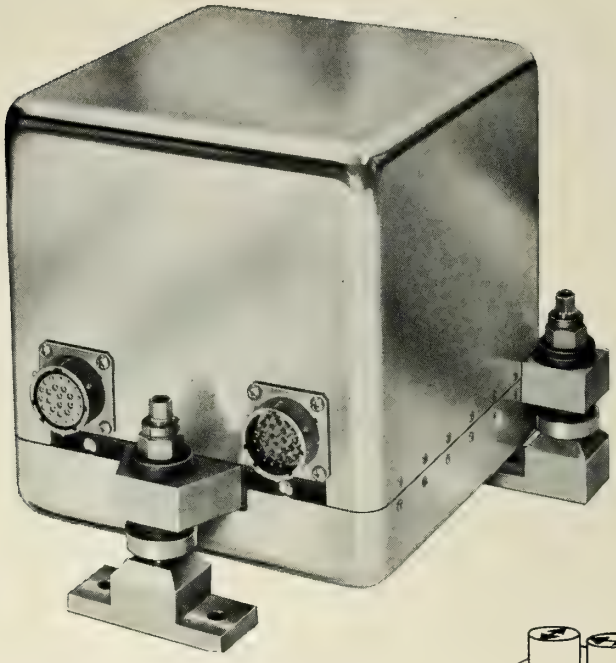

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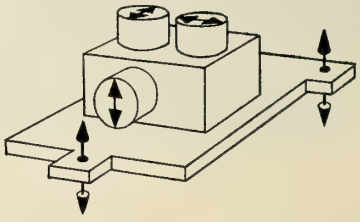

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Bullpup (AGM-12 B & C) (Navy, Air Force)

TYPE: Air-to-surface missile

STATUS: Operational

PRIME CONTRACTOR: Maxson Electronics Corp.

FRAME TYPE & CONFIGURATION: B: length, 11 ft.; diameter, 12 in.; weight, 573 lbs. C: length, 13.5 ft.; diameter, 18 in.; weight, 1,800 lbs.

PROPULSION CONTRACTOR: Thiokol

PROPULSION TYPE: Both B and C versions have prepackaged liquid propellant engines (LR58 and LR62)

GUIDANCE CONTRACTOR: Maxson

GUIDANCE TYPE: Radio-link command guidance from firing aircraft; pilot uses visual reference

PAYLOAD: High-explosive warhead weighing 250 lbs.; 1,000-lb. nuclear or conventional warhead on Bullpup B

PERFORMANCE: Range, 6 n.mi. (depending on launch altitude of aircraft); speed, 1,400 mph; extremely accurate against hardpoint targets

REMARKS: C version being procured by the Navy for itself and Air Force for use on tactical aircraft; being produced in Europe for NATO

Condor (AGM-53) (Navy)

TYPE: Air-to-surface

STATUS: Project definition

PRIME CONTRACTOR: In-house, Naval Ordnance Test Station

CONFIGURATION: Classified

GUIDANCE: TV/radio command

REMARKS: Intended for use with F-111B; Navy describes the system as a medium-range missile; Northrop/Norair and North American/Columbus have PDP study contracts; work to be finished October, 1965

BULLPUP

ZUNI

Hornet (ZAGM-64A) (Air Force)

TYPE: Air-to-surface missile (formerly known as ATGAR)

MISSION: anti-tank weapon

STATUS: Pre-development

PRIME CONTRACTOR: North American/Columbus (on the basis of an unsolicited proposal)

GUIDANCE: Electro-optical

REMARKS: North American/Columbus received a $1.3-million contract in March, 1965, to build additional test missiles for use at Air Force Air Proving Ground Center, Eglin AFB, Fla.

Hound Dog (AGM-28) (Air Force)

TYPE: Air-to-surface strategic defense-supression missile

STATUS: Operational

PRIME CONTRACTOR: North American

FRAME TYPE & CONFIGURATION: Air-breathing cruise type; length, 42.5 ft.; wingspan, 12.2 ft.; height, 9.3 ft.; weight, 9,600 lbs.

PROPULSION CONTRACTOR: Pratt & Whitney

PROPULSION TYPE: J52 turbojet generating 7,500 lbs. thrust at sea level

GUIDANCE CONTRACTOR: North American Autonetics

GUIDANCE TYPE: All-inertial

PAYLOAD: Nuclear warhead

PERFORMANCE: Range, over 600 n.mi.; speed, over Mach 2; ceiling, over 50,000 ft.

REMARKS: Standoff weapon, Hound Dog will be retained in SAC arsenal for suppression of enemy defenses so that B-52 bombers can penetrate to top-priority targets with primary bomb load; procurement complete with stockpile over 400 missiles

Quail (ADM-20C) (Air Force)

TYPE: Decoy to simulate B-52 bombers

STATUS: Operational

PRIME CONTRACTOR: McDonnell

FRAME TYPE & CONFIGURATION: Length, 12.9 ft.; height, 3.3 ft.; wingspan, 5.5 ft.; width (with wings folded), 2.5 ft.

PROPULSION CONTRACTOR: General Electric

PROPULSION TYPE: J85 turbojet generating 2,450 lbs. thrust

GUIDANCE CONTRACTOR: Guidance Technology, Inc.

GUIDANCE TYPE: Gyroscopic autopilot

PAYLOAD: B-52 electronic simulation and electronic countermeasures equipment

EQUIPMENT CONTRACTORS: TRW, Inc., electronic payload; support system contractor, Bell Aerospace

PERFORMANCE: Range, 250 n.mi.; advanced version, over 400 n.mi.; speed, comparable to B-52; ceiling, over 50,000 ft.

REMARKS: Each B-52 bomber carries Quail decoys to release as it approaches enemy defenses; bomber and decoys fly B-52 style patterns, speed and altitudes over wide area to maximize enemy confusion

Shrike (AGM-45A) (Navy)

TYPE: Air-to-surface anti-radiation missile

STATUS: Operational

PRIME CONTRACTOR: Naval Ordnance Test Station

FRAME TYPE & CONFIGURATION: Similar to Sparrow III configuration

PROPULSION CONTRACTOR: Rocketdyne

PROPULSION TYPE: Solid propellant

GUIDANCE CONTRACTOR: Texas Instruments

GUIDANCE TYPE: Passive all-weather radar-homing

PAYLOAD: High-explosive warhead

REMARKS: Designed for firing by attack aircraft against enemy radar-controlled air defenses and other radar installations; AF also procuring for TAC

SS-11 (Army)

TYPE: Air-to-surface anti-tank missile

STATUS: Operational

PRIME CONTRACTOR: Nord Aviation

FRAME TYPE & CONFIGURATION: Length, 46 in.; diameter, 6 in.; wingspan, 20 in.; weight, 63 lbs.; swept-back cruciform wings

PROPULSION TYPE: Solid propellant

GUIDANCE TYPE: Wire-guided

PAYLOAD: High-explosive shaped charge

PERFORMANCE: Range, 3,800 yds.; speed, over 400 mph

REMARKS: Employed on UH-1B helicopter with 6-missile launcher

Walleye (Navy)

TYPE: Guided, air-to-surface bomb

STATUS: Engineering development

PRIME CONTRACTOR: Naval Ordnance Test Station

FRAME TYPE & CONFIGURATION: 1,000-lb. bomb equipped with movable fins

PROPULSON TYPE: None

PERFORMANCE: Range of several miles

GUIDANCE CONTRACTOR: Naval Ordnance Test Station

GUIDANCE TYPE: TV contrast homing guided by pilot after launch

PAYLOAD: High-explosive warhead

REMARKS: To be carried by attack aircraft; highly accurate

Zuni (Navy)

TYPE: Air-to-surface rocket for bombardment of ground targets

STATUS: Operational

PRIME CONTRACTOR: Naval Ordnance Test Station

FRAME TYPE & CONFIGURATION: Folding fin, all-weather rocket; length, 9.2 ft.; diameter, 5 in.; weight, 107 lbs. Hunter-Douglas Div., Bridgeport Brass Co.

PROPULSION CONTRACTOR: Naval Propellant Plant

PROPULSION TYPE: Solid propellants

GUIDANCE TYPE: Unguided

PAYLOAD: High-explosive warhead

PERFORMANCE: Range, about 5 n.mi.; speed, over Mach 2

REMARKS: Used on many Navy attack and fighter aircraft; AD-type can carry 48; extremely effective as a barrage rocket against ground targets

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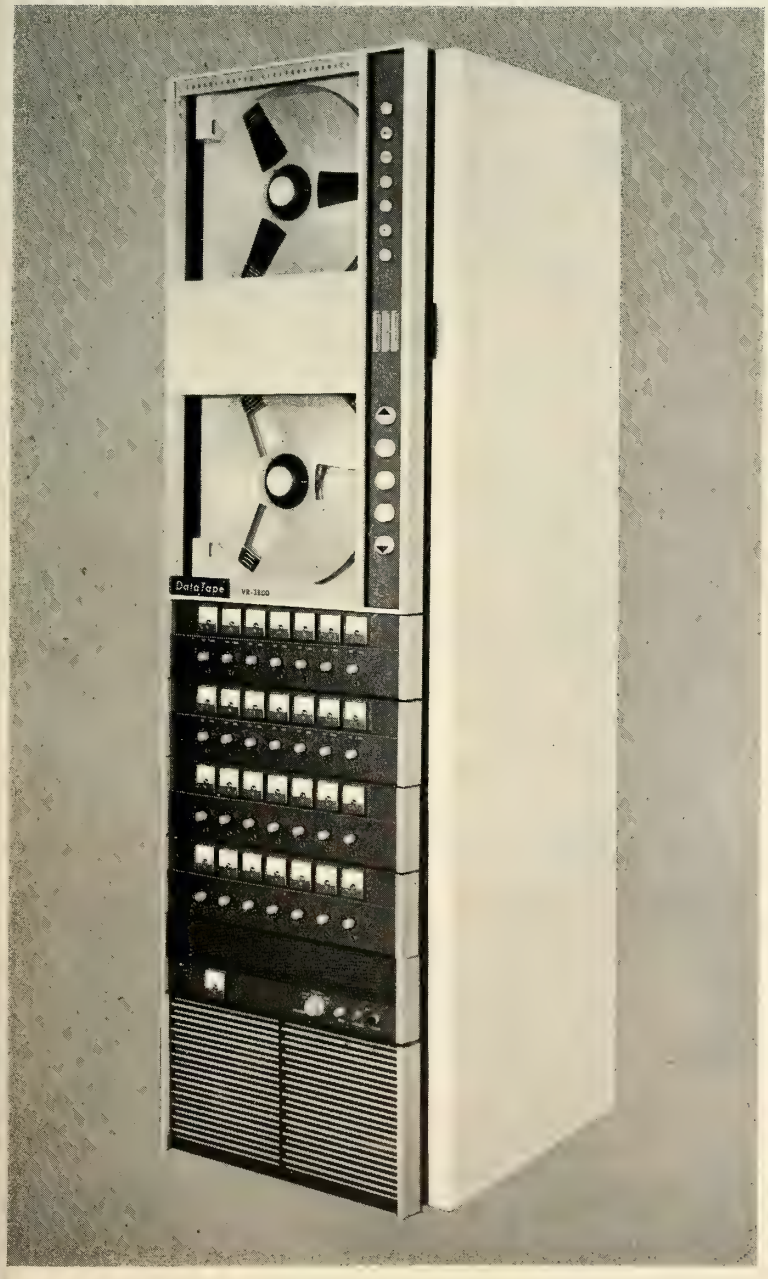

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AQM-37A Target Drone

MISSION: Supersonic target drone designed for air-to-air and surface-to-air weapon system testing and training

STATUS: Production

PRIME CONTRACTOR: Beech

PERFORMANCE: Max. speed, Mach 2; service ceiling, 70,000 ft.

CONFIGURATION: Span, 39 in.; length, 161 in.; diameter (body), 13 in.; weight, 560 lbs.; frame, swept delta wings with canard controls

CONTROL SYSTEM: Two-axis autopilot

PROPULSION SYSTEM: One Rocketdyne liquid-propellant engine with 630 lbs. thrust

REMARKS: Used by Navy; expendable

Bikini Photo Recon Drone

MISSION: Provide battlefield commanders with small, lightweight photo reconnaissance drone

STATUS: Operational (limited use only)

PRIME CONTRACTOR: Republic

PERFORMANCE: Max. speed, 100 mph; endurance, 45 min.; altitude, 10,000 ft.; recon range radius, 10 mi.

CONFIGURATION: Resembles large model airplane; weight, approx. 50 lbs. including camera payload; major materials, reinforced plastic and off-the-shelf model airplane parts

GUIDANCE: Radio command; four-channel for rudder, throttle setting, camera activation and recovery parachute deployment

PROPULSION: 2-cycle, 2-cylinder, 4½-hp engine driving a propeller

REMARKS: Low-cost vehicle designed for Marine Corps at battalion level; can be operated by two men throughout mission

CL89/XC1 Reconnaissance Drone (Canadian and British Armies)

MISSION: Gather battlefield intelligence; operates under conditions hazardous for piloted reconnaissance aircraft

STATUS: Under flight test at Yuma Test Station, Ariz., by U.S. Army

PRIME CONTRACTOR: Canadair Ltd., Cartierville, Quebec

PERFORMANCE: Not available

CONFIGURATION: Approximately 102 in. long by 37 in. in diameter, including four movable fins; drone fuselage diameter about 13 in.; launch weight, 220 lbs.

GUIDANCE: Not available.

PROPULSION: Williams Research Corp. turbojet engine with rocket assist

SUPPORT EQUIPMENT: Zero-length launcher; parachute recovery with air-bag cushions

REMARKS: The CL89 project is the result of a common need for a low-cost drone for the Canadian and British armies and the two governments' attempts to reduce costs; first project in which the two countries have cooperated so extensively

Firebee Target Drone (Army, Navy, Air Force)

MILITARY DESIGNATION: BQM-34A (Navy, Air Force); MQM-34D (Army)

STATUS: Operational

PRIME CONTRACTOR: Ryan

PERFORMANCE: Max. speed, 625 mph; service ceiling, 60,000 ft.; endurance, 75 to 96 min. at 50,000 ft.

CONFIGURATION: Span, 153 in.; length, 274 in.; height, 79 in.; max. weight, 2,500 lbs.

GUIDANCE: Radio command and radar

PROPULSION SYSTEM: One Continental J-69-T-29 with 1,700 lbs. thrust

SUPPORT EQUIPMENT: Air- or ground-launched; recoverable by parachute

REMARKS: Primary using commands are Navy, fleet training; RDT&E; USAF, Air Defense Command; Army Missile Command, Air Defense Center

Jindivik MK-3A Target Drone

STATUS: Operational

PRIME CONTRACTOR: LTV Aerospace Corp.

PERFORMANCE: 100 ft. to 65,000 ft. operational altitudes; Mach 0.86

CONFIGURATION: Wing-tip extensions for very-high-altitude flight; span, 25 ft. 8 in.; length, 26 ft. 9 in.; gross weight, 3,100 lbs.

PROPULSION SYSTEM: Bristol-Siddeley Viper turbojet, 2,500 lb. thrust

REMARKS: Operated by LTV for U. S. Navy as target for surface-to-air and air-to-air missile systems on Pacific Missile Range; Jindivik can carry variety of special weapons-evaluation equipments and is equipped with electronic and photographic scoring systems

MQM-15A Target Drone (Navy)

STATUS: Operational

PRIME CONTRACTOR: LTV Aerospace Corp.

PERFORMANCE: Mach 2.0 at 57,000 ft.

CONFIGURATION: Span, 240 in.; length, 684 in.; diameter (body), 72 in.

GUIDANCE: Radio command

PROPULSION SYSTEM: Booster, Aerojet 115,000-lb.-thrust solid-propellant motor; sustainer, one General Electric J79 engine with afterburner

REMARKS: Target version of the Regulus II missile; limited production; flown as a target for air defense missile systems

MQM-33A, 33B Aerial Target (Army, AF) MQM-36A (Navy)

MISSION: Target for gunnery and missile training and evaluation

STATUS: Operational

PRIME CONTRACTOR: Northrop Ventura

PERFORMANCE: Max. speed, 220 mph; stalling speed, 70 mph; rate of climb, 3,350 fpm; service ceiling, 23,000 ft.; endurance, 60 min.

CONFIGURATION: Span, 138.0 in., with pods 158.5 in.; length, 147.0 in.; height, 31.3 in.; total weight, 326.8 lbs.; with pods 353 lbs.

FLIGHT CONTROL: RPS-1A VHF command control system (MQM-33B); C-24 UHF proportional command control system with automatic stabilization (MQM-36A)

PROPULSION SYSTEM: 2-cycle, 4-cylinder, flat-opposed, air-cooled, McCullough Motors engine, driving a fixed-pitch, 44-in.-dia. wooden propeller. Fuel capacity 11.3 gal.

PAYLOAD: For radar appearance augmentation, two wing-tip reflector pods are added to MQM-33A; standard on MQM-33B and MQM-36A

SUPPORT EQUIPMENT: MQM-33A; ground-launched; MQM-36A, ground-launched only; catapult, rotary or zero-length launchers used; single parachute 38-ft.-dia. (MQM-33A) or 32-ft. used for recovery

REMARKS: New model uses 6-cylinder engine for increased performance

MQM-39A Target Drone (Navy)

MQM-61A Target Missile (Army)

MISSION: Provides "out of sight" target for surface-to-air and air-to-air missiles

STATUS: Operational

PRIME CONTRACTOR: Beech

PERFORMANCE: Max. speed, 340 mph.; service ceiling, 40,000 ft.; endurance, 60 min. on station

CONFIGURATION: Span, 155 in.; length, 181 in.; diameter (body) 17¾ in.; weight, 635 lbs.

GUIDANCE: Radio command

CONTROL SYSTEM: Beech two-axis gyroscope autopilot

PROPULSION SYSTEM: One McCullough turbo-supercharged, 125-hp engine with Beech constant-speed propeller

SUPPORT EQUIPMENT: Launched from zero-length launcher; parachute-recovered

REMARKS: The two missile targets designated above are identical in their external configuration, and performance noted above is applicable to both targets

MQM-39A Turbojet Target Drone (Navy)

MQM-61A Turbojet Target Drone (Army)

MISSION: Provides "out-of-sight" target for surface-to-air and air-to-air missiles

STATUS: Operational

PRIME CONTRACTOR: Beech

PERFORMANCE: Max. speed, mach 0.8; service ceiling above 40,000 ft.; endurance over one hour

CONFIGURATION: Span, 12.1 ft.; length, 17 ft.; diameter, 1.5 ft.; weight, 999 lbs., without launch booster

GUIDANCE: Radio command

CONTROL SYSTEM: Beech two-axis gyroscope autopilot

PROPULSION SYSTEM: One Continental 321-2 turbojet

SUPPORT EQUIPMENT: Launched from zero-length launcher; parachute-recoverable

REMARKS: This drone is the turbojet configuration of both the standard MQM-39A and MQM-61A target drones

MQM-57A Surveillance Drone (Army)

MISSION: Tactical battlefield surveillance drone capable of performing remote-controlled photo and other sensory missions

STATUS: Operational

PRIME CONTRACTOR: Northrop Ventura

PERFORMANCE: Max. speed, 160 mph; stalling speed, 95 mph; rate of climb, 1,500 fpm; service ceiling, 15,000 ft.; endurance, 35 min.

CONFIGURATION: Span, 138.1 in.; Length, 160.9 in.; height, 31.4 in.; empty wt., 354.0 lbs.; useful payload, 88.0 lbs.; total wt., 442.0 lbs.

FLIGHT CONTROL: Modified C-2A proportional-type command control system

TRACKING SYSTEM: AN/DPN-62 beacon (passive reflector pods optional) and an AN/MPQ-29 ground tracking system; night lights for visual tracking

PROPULSION SYSTEM: Modified, four-cylinder, horizontally opposed, two-cycle, air-cooled engine (fuel capacity 5.6 gal.)

PAYLOAD: 88 lbs. of photographic or other sensory equipment

SUPPORT EQUIPMENT: Zero-length launcher; single-stage 44-ft. recovery parachute

REMARKS: Only operational surveillance drone in the Army inventory; also being used by British troops

MQM-58A

MISSION: Tactical battlefield surveillance

STATUS: Production

PRIME CONTRACTOR: Aerojet-General

PERFORMANCE: Max. speed, 345 mph; endurance, 45 min.

CONFIGURATION: Span, 156 in.; length, 192 in.; launch wt. (less boosters), 1,013 lbs.

GUIDANCE: System contractor, ITT; type, radio command

PROPULSION SYSTEM: System contractor, Lycoming; type, 1 IMO-360BIB, 225-hp engine; drone also uses 2 JATO units for launch from its zero-length launcher.

PAYLOAD: Photographic and other sensory equipment

SUPPORT EQUIPMENT: Launched from Army 2½-ton truck

REMARKS: A modified version of the MQM-58A capable of performing chemical missions

NV-101 Autogyro Drone Aircraft

MISSION: Helicopter target simulation, fixed aerial communications relay, battlefield surveillance, logistics

STATUS: Under development

PRIME CONTRACTOR: Northrop Ventura

PERFORMANCE: Maximum speed, 160 mph; stalling speed, 20 mph; rate of climb, 1,700 fpm; service ceiling, 14,000 ft.; endurance, 60 min.; jump takeoff, zero velocity; land speed, zero (flareout)

CONFIGURATION: Length, 12 ft., 4 in.; height, 3 ft. 9 in.; rotor blade diameter, 24 ft.; weight 600 lbs. (including 290-lb. payload)

FLIGHT CONTROL: Radio-controlled, both in and out of sight

PROPULSION SYSTEM: McCullough 0-100-1 two-cycle 72-hp. engine; preflight rotor spin-up by compressed air or small propellant charge

PAYLOAD: 290 lbs.

SUPPORT EQUIPMENT: Ground launcher with pneumatic rotor blade starter

REMARKS: Has been successfully flight demonstrated at Pt. Mugu, Calif., and White Sands Missile Range, N.M.; considered the world's only autogyro drone

NV-104 Advanced Surveillance Drone (Army)

MISSION: Battlefield surveillance drone capable of performing remote-controlled photo and other sensory missions

STATUS: Under military evaluation

PRIME CONTRACTOR: Northrop Ventura

PERFORMANCE: Maximum speed, 250 mph.; altitude, 27,600 ft.; endurance, 210 miles or 45 min.; rate of climb, 3,600 fpm.

CONFIGURATION: Span, 11 ft. 2 in.; length, 14 ft. 9 in.; payload volume, 5 cubic ft.; payload weight, 150 lbs.

FLIGHT CONTROL: Modified C-2A proportional-type command control system

TRACKING SYSTEM: AN/DPN-62 beacon and AN/MPQ-29 ground tracking system; night lights for visual tracking

PROPULSION SYSTEM: 250-hp T-63 Allison turbojet engine

SUPPORT EQUIPMENT: Zero-length launcher; recovery parachute

REMARKS: An improved version of the Army's only operational surveillance drone, the NV-104 is capable of doubling the present surveillance drone's performance while using 98% of its existing ground support equipment

NV-105 Target Drone

MISSION: Low-cost, medium-performance target for surface-to-air gunnery and missile system training

STATUS: Development

PRIME CONTRACTOR: Northrop Ventura

PERFORMANCE: Maximum speed, 175-400 knots; maximum altitude 35,000 ft.; endurance (at 20,000 ft.) 67 min. at full power

CONFIGURATION: Span, 52.0 in.; length, 156.0 in.; vertical height, 23.0 in.; launch weight, 335 lbs.

FLIGHT CONTROL: Radio-command, both in and out of sight

PROPULSION: Williams Research Corp WR2-4 turbojet, 105 lbs. thrust

SUPPORT EQUIPMENT: Zero-length launcher, recovery parachute

REMARKS: Design completed; test vehicles available August and first flight demonstrations scheduled for September 1965

Redhead/Roadrunner (Army)

MILITARY DESIGNATION: MQM-42A

MISSION: Supersonic target missile

STATUS: Production

PRIME CONTRACTOR: Columbus Div., North American Aviation, Inc.

PERFORMANCE: Operates from Mach 0.9 through Mach 2 and from 300 ft. to 60,000 ft.

CONFIGURATION: Span, 70.12 in.; length, 298.4 in. for supersonic missions and 262.3 in. for subsonic missions; diameter (body) 12 in.; weight (recovery) 434 lbs.

GUIDANCE: System contractor, NAA; type, radio command

PROPULSION SYSTEM: Booster: one 5,500-lb.-thrust Rocketdyne solid motor; sustainer: one Marquardt ramjet engine

SUPPORT EQUIPMENT: Parachute-recoverable

REMARKS: Designed for both low- and high-level missions at either subsonic or supersonic speeds

Rocket Powered Target Drone (Army, Navy)

MILITARY DESIGNATION: AQM-38A

MISSION: Target for surface-to-air and air-to-air weapon systems

STATUS: Operational

PRIME CONTRACTOR: Northrop Ventura

PERFORMANCE: Supersonic version: max. speed, Mach 1.3; service ceiling, 75,000 ft.; endurance 30 min.; subsonic version: max. speed, Mach 0.9; ceiling, 61,800 ft.; endurance, 30 min.

CONFIGURATION: Span, 60 in.; length 116 in.; height 18 in.; max. weight 301 lbs.

INSTRUMENTATION: Six data channels on the tracking-aid RF link for scoring

FLIGHT CONTROL: Automatic with command control override

PROPULSION SYSTEM: Solid-propellant rocket engine with twin thrust nozzles canted 15 degrees outboard in a horizontal plane

SUPPORT EQUIPMENT: Launched from a fighter-type aircraft; recovered by 3-ft. ribbon brake chute and 24-ft.-dia. main chute

REMARKS: Used extensively by the Army for annual service practices of Nike-Hercules and Hawk units around the world

RP-76-200 Rocket Powered Target Aircraft

MISSION: Air-to-air and surface-to-air supersonic target missile; simulates large enemy bomber or missile

STATUS: Under military evaluation

PRIME CONTRACTOR: Northrop Ventura

PERFORMANCE: Speed, Mach 2.25; rate of climb, 10,000 fpm; ceiling 80,000 ft.; duration, 4 min. powered, 30 min. glided control

CONFIGURATION: Span, 4 ft., 4 in.; length, 11 ft.; fuselage diameter, 1 ft.

FLIGHT CONTROL: Air-launched from fighter-type aircraft and controlled from the ground by radio

PROPULSION SYSTEM: 200-lb.-thrust solid propellant rocket engine

SUPPORT EQUIPMENT: Recovery parachute

REMARKS: Successfully flight demonstrated at White Sands Missile Range, N.M.

Systems Analysts & Preliminary Design Engineers for Advanced Space Guidance & Control Systems

Rapid expansion of space contracts, projects and studies at the HUGHES Aerospace Divisions in Southern California has created unusual opportunites for several qualified Engineers, Physicists and Mathematicians for Advanced Space Systems assignments.

Space-mission openings are available in the following areas:

- **INTERPLANETARY GUIDANCE & NAVIGATION**
- **TRANS-LUNAR GUIDANCE & NAVIGATION**
- **EARTH ORBIT NAVIGATION**
- **RENDEZVOUS & RE-ENTRY GUIDANCE**

Current requirements include:

Guidance & Navigation System Synthesis

To study and develop guidance and navigation equations and techniques; make feasibility and error analyses; establish subsystem and component requirements; conduct system preliminary design; plan inertial, optical and electro-magnetic instrumentation.

Control System Synthesis

To analyze control system requirements for various space vehicles; establish subsystem and component requirements; conduct system preliminary design; study measurement instrumentation and torque-producing equipment.

Simulation

To plan digital simulation for studies related to earth orbital, trans-lunar, interplanetary and reentry trajectories; analog simulation of rendezvous guidance and control systems.

Applied Mathematics

Space mathematics applications related to orbit determination, trajectory analysis, optimization procedures, perturbation theory and space mechanics.

If you hold an accredited Engineering, Physics or Mathematics degree, are a U. S. citizen and feel that you are qualified by interest and experience in one or more of these areas, please airmail your resume to:

MR. ROBERT A. MARTIN
Head of Employment
HUGHES Aerospace Divisions
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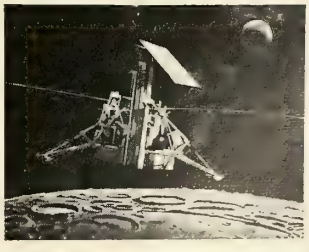
Culver City 44, California



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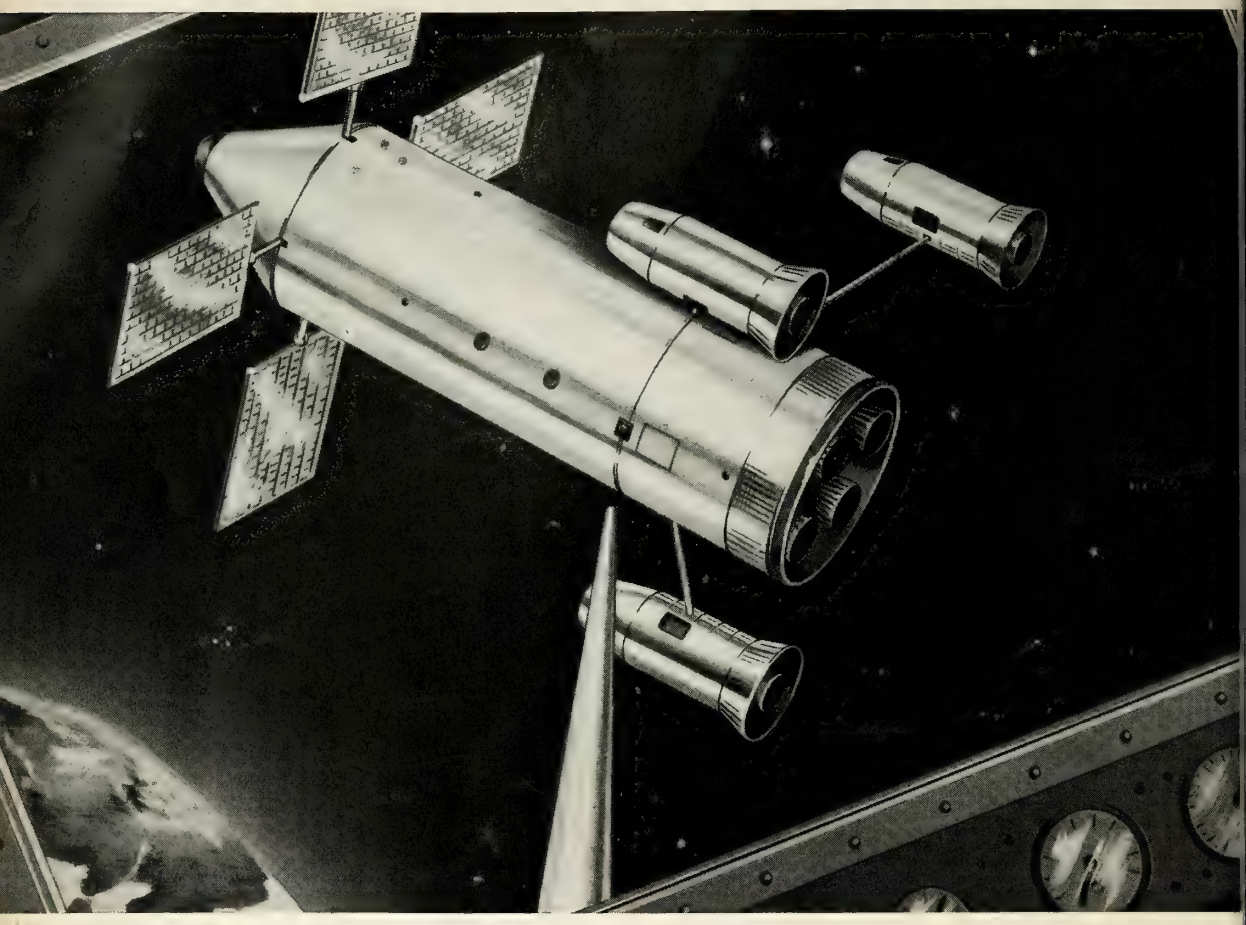
low to dock a spacecraft without rocking the boa

(Read how de Havilland's system using the STEM technique avoids dangerous impact)



First a word about STEM (Stored Tubular Extendible Member): Strip metal is heat-treated into a circular section so that the edges overlap by approximately 180°. This tube has a bending strength almost equal to a seamless tube of the same diameter and thickness. *But is much lighter.*

Starting at one end, the tube is unbent and wound flat onto a drum. This means the tube is wound under strain. With a natural tendency to unwind and become a tube again. This stored energy can be used to extend the tube. (Or it can be extended and retracted by motor.)

The beauty of the STEM technique is that a long, rigid boom can be stored in a minimal amount of space. And can be extended and retracted quickly and simply.

How the STEM technique applies to docking spacecraft: In this application, the STEM technique is a boom system.

A 20 ft. motor-driven extendible boom attaches one spacecraft to another. When retracted, it pulls the two craft together.

The advantage of this system over conventional docking concepts is that the pilot can see the other craft up to and during attachment.

Catastrophic impact between the two craft is avoided. And final docking is carried out simply. Without the need for complex terminal guidance systems.

The STEM boom package weighs only 72 lbs. and measures only 24″ long, 12″ wide and 12″ deep.

The STEM technique overcomes size, weight, packaging, density, and structural problems for other aerospace projects.

STEM developments for space programs include communication antennas, long gravity-gradient orientation booms, attitude control devices, despin and stabilization devices, lunar surface sensing probes and couplings for space structures.

STEM devices have been used or are presently in use in Alouette, LOFTI, NASA Javelin, Scouts, TRAAC, Transit, POGO, Mercury, Gemini, Apollo and other space programs.

For more information on the versatility of the STEM technique, please write to the Sales Department.

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SPECIAL PRODUCTS & APPLIED RESEARCH DIVISION

MALTON ONTARIO

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AUSTRALIA

Aero-High (sounding rocket)

STATUS: Operational

PRIME CONTRACTOR: Weapons Research Establishment, Salisbury, South Australia

PERFORMANCE: Carries 45-lb. payload to more than 130 mi.; maximum speed, 5,000 mph at second-stage burnout

CONFIGURATION: Two-stage solid propellant; first stage, 10 in. dia. and 11 ft. long; second stage, 8.3 in. dia. and 10 ft. long; launch weight, 900 lbs.

REMARKS: Test vehicle developed primarily to carry out "chemical seeding" experiments at high altitudes.

HAD (sounding rocket)

STATUS: Operational

PRIME CONTRACTOR: Weapons Research Establishment, Salisbury

PERFORMANCE: 3,200 mph at second-stage burnout; 20-lb. payload to 80 mi.

CONFIGURATION: Two-stage solid; length, 19½ ft.; second-stage diameter 5 in.; launch weight, 640 lbs., weight of second stage, 115 lbs.

CODE MEANING: HAD=High-Altitude Density

HAT (sounding rocket)

STATUS: Operational

PRIME CONTRACTOR: Weapons Research Establishment, Salisbury

PERFORMANCE: Carries 20-lb. payload to 40 mi.

CONFIGURATION: Length, 17½ ft.; second-stage diameter, 5 in., launch weight, 540 lbs., second-stage weight, 115 lbs.

CODE MEANING: HAT=High-Altitude Testing

REMARKS: Developed for use in development of a drop sonde

Ikara (antisubmarine)

STATUS: R&D

PRIME CONTRACTOR: Weapons Research Establishment

REMARKS: No data released beyond fact it may be a torpedo carrier; Australian sources claim U.S. has invested $4 million in research

Jabiru (research rocket)

STATUS: Operational

PRIME CONTRACTOR: Weapons Research Establishment in Australia jointly with Royal Aircraft Establishment in U.K.

CONFIGURATION: Length, 39 ft.; three-stage solid; first-stage diameter, 1.43 ft.; span, 6.33 ft.; launch weight, 3,700 lbs.

GUIDANCE: None.

PAYLOAD: 55-lb. instrumentation head

PERFORMANCE: 6,400 mph at third-stage burnout, up to Mach 10 in level flight between 80,000 and 100,000 ft.

REMARKS: Known in U.K. as Jaguar

Long Tom (sounding rocket)

STATUS: Operational

PRIME CONTRACTOR: Weapons Research Establishment, Salisbury

PERFORMANCE: 30-lb. payload to over 100 mi. or 180-lb. payload to 68 mi.; 3,500 mph at second-stage burnout

CONFIGURATION: Two-stage solid; first stage cluster of three rockets; second-stage diameter 9.2 in.; launch weight, 2,000 lbs.; length, 27 ft.

REMARKS: Woomera rocket range instrumentation test vehicle for ground and airborne instrumentation; evolved into "workhorse" capability; also used to measure micrometeorite prevalence and for high-altitude photography

Malkara (anti-tank)

STATUS: Operational

PRIME CONTRACTOR: Government Aircraft Factories (Australia)

PERFORMANCE: Range, 2 mi.; has received extensive anti-bunker and jungle evaluation.

CONFIGURATION: Length, 6½ ft.; weight, about 200 lbs., span, 2 ft. 8 in.

GUIDANCE: Wire

EUROPEAN AGENT: British Aircraft Corp. handles European export sales

PROPULSION: Two-stage solid

HAT

MALKARA

CANADA

Alouette (satellite)

STATUS: R&D

PRIME CONTRACTOR: Canadian Defense Research Telecommunications Establishment

PERFORMANCE: First in planned series successfully orbited Sept. 28, 1962, by Thor-Agena B from Point Arguello, Calif.; still transmitting ionosphere data

CONFIGURATION: Nearly oval; 42-in. dia.; 320 lbs.; 6,500 solar cells; one 150-ft.-long antenna, one 75-ft.-long antenna

REMARKS: First non-Soviet, non-U.S. satellite in space; all-Canadian fabrication; Alouette B will be launched in last half of 1965 as part of NASA's continuing joint international program with Canada

ISIS (satellite)

TYPE: Scientific

MISSION: To study ionosphere as a follow-on to the Alouette satellite; weight 350 lbs.

STATUS: R&D

CONTRACTOR: Canadian Defense Research Board

BOOSTER: Thor-Agena

REMARKS: Three-satellite series, A, B, and C, will be launched by NASA beginning in 1967; other shots scheduled for 1968 and 1969

Black Brant (sounding rockets)

STATUS: Family of sounding rockets; BB III, BB IV and BB V-A operational; BB V-B in fiinal development

PRIME CONTRACTOR: Canadian Bristol Aerojet Ltd., Winnipeg

PERFORMANCE: BB III, 50 lbs. to 100 mi., impact range at 85° launch angle, 46 mi.; maximum velocity, 6,627 fps; maximum longitudinal acceleration, 30 g; BB IV, 40 lbs. to 620 mi.; impact range at 85° launch angle, 365 mi.; maximum velocity, 13,353 fps; maximum longitudinal acceleration, 44 g; BB V-A, 150 lbs. to 145 mi.; impact range at 85° launch angle, 119 mi.; maximum velocity, 6,037 fps; maximum longitudinal acceleration, 16 g; BB V-B, 175 lbs. to 268 mi.; impact range at 85° launch angle, 144 mi.; maximum velocity, 8,530 fps; maximum longitudinal acceleration 16 g

WEIGHTS: Nose assembly (less net payload): BB III and BB IV, 35 lbs.; BB V-A and BB V-B, 55 lbs.; launch weight (less net payload); BB III, 625 lbs.; BB IV, 3,097 lbs.; BB V-A, 2,458 lbs.; BB V-B, 2,805 lbs.

CONFIGURATION: BB III, single stage, solid propellant, 10 in. dia., 18.5 ft. length, unguided 3 finned, launched from standard boom-type launcher; BB IV, two stages; first stage uses 17.2-in.-dia. engine used on single-stage BB V-A; second stage similar to production stage of BB III but with a new nozzle and a conical stabilizer replacing the fins and aft body; BB V-A, solid propellant motor providing 4.92 cu. ft. payload volume; BB V-B, similar to BB V-A

REMARKS: BB III, standard telemetry and payload separation and recovery systems are available; BB IV will carry a number of scientific payloads now under development; BB V-A, used by Canadian and U.S. scientific agencies for upper atmospheric research

EGYPT

Al Ared (Pioneer) (missile)

TYPE: Surface-to-surface

STATUS: Development

CONFIGURATION: Two-stage, liquid propellants

PERFORMANCE: Range, 600 mi.

REMARKS: Reportedly suffering from unreliable guidance system, as are other UAR rockets

Al Kaher (Conqueror) (missile)

TYPE: Surface-to-surface

STATUS: Production

PERFORMANCE: Range, 372.6 mi.

CONFIGURATION: Single-stage, liquid-fueled

REMARKS: Twenty missiles in July 23, 1962, parade in Cairo; first public announcement of launching made July 21, 1962

Al Zafer (Victorious) (missile)

TYPE: Surface-to-surface

STATUS: Production

PERFORMANCE: Range, 235.9 mi.

CONFIGURATION: Single-stage, liquid-fueled

REMARKS: First public test launching July 21, 1962; about 300 Al Zafer and Al Kaher missiles have reportedly been manufactured

Star (satellite)

TYPE: Electromagnetic research

STATUS: R&D

REMARKS: Details unknown, but the program is under direction of Dr. Wolfgang Pilz; the Heliopolis center near Cairo is developing a launch vehicle based on Al Ared; a nominal 300-mi. orbit is expected for the first version and a larger follow-on project has been reported

EUROPE: JOINT PROGRAMS

Blue Streak (space booster)

STATUS: Development and flight test

PRIME CONTRACTOR: Hawker Siddeley Dynamics, United Kingdom

CONFIGURATION: Length, 61 ft., 6.3 in.; lift-off weight 207,579 lbs. with propellants assuming 193,892 lbs.; when empty, shell pressurization required at 5 psi

PROPULSION: Twin Rolls-Royce LOX/RP1 engines, designated RZ.12, developing combined thrust of 300,000 lbs.; I_{sp} 245 at liftoff, developing 150,000 lbs. thrust

REMARKS: First stage of European Space Vehicle Launcher Development Organization (referred to as ELDO in this issue) space rocket; first launch June 5, 1964, from Woomera, Australia, fell slightly short due to premature cutoff; after adjustment of autopilot gain, two subsequent flights were fully successful; next three shots will have dummy upper stages, total vehicle length 104 ft.; four more shots planned with live upper stages and with dummy test satellite being built by Italians

Coralie (rocket)

TYPE: Second stage of ELDO

STATUS: Development

RESPONSIBLE AGENCY: CNES and Defense Ministry

PRIME CONTRACTOR: Nord Aviation and Laboratoire de Récherches Balistiques et Aerodynamiques

CONFIGURATION: Lengh, 19 ft., diameter, 6.56 ft.; empty wt., 3,850 lbs., loaded wt., 25,300 lbs.; four movable nozzles, integral tankage

PROPULSION: Nitrogen-tetroxide/unsymmetrical dimethylhydrazine generating 56,000 lbs. thrust at I_{sp} of 277 sec. (vacuum) for 97 seconds burning time; UDMH coats nozzles for cooling; propellants also used for gas generator

PERFORMANCE: Slated for first ELDO vehicle, to put third stage (7,260 lbs.) and payload (1,000 kg) into orbit

REMARKS: Test-fiired in February, 1964, successfully at Vernon, France; on schedule wih four future flight tests slated (single stage) to get aerodynamic, propulsion and structural data; flight tests slated at Hammaguir, Algeria

ELDO Third Stage (booster stage)

TYPE: ELDO satellite booster

STATUS: Development

PRIME CONTRACTOR: Entwicklungsring Nord (ERNO) and Boelkow-Entwicklungen KG, West Germany

MISSION: 1.2 tons in low orbit; 400 lbs. in high orbit

CONFIGURATION: Loaded weight, about 8,000 lbs.; empty weight, about 1,100 lbs.

SIZE: Diameter, 6½ ft.; length, 11.2 ft.

GUIDANCE: Radio-inertial, two vernier rockets

TELEMETRY: Will carry on-board equipment

PROPULSION: Hypergolic; aerozene and Nitrogen Tetroxide; main engine, 5,000 lbs. thrust

REMARKS: ASAT (Arbeitsgemeinschaft Satellitentrager) is German Satellite Carrier Advisory Group responsible for third-stage development work for the ELDO program; total ASAT development cost estimated at $60 million; first static firing occurred April 1, 1965; first live third stage will be inserted into orbit in 1967

New Cubic systems will help pinpoint battlefield targets with accuracy never before achieved!

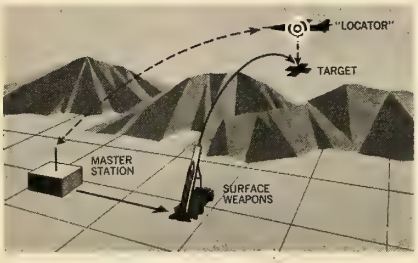
Deadly accurate electronic systems from Cubic Corporation will help eliminate target location guesswork. They answer the long-standing need for a means of "locating the locator" in targeting.

In today's highly fluid battlefield environment, it is not enough to know only where the target is relative to a "locator" (man, aircraft, drone, helicopter). What must be known is the precise position of the "locator" when it sees the target. Cubic's targeting systems accomplish this instantaneously and accurately.

System concept...

Cubic systems continuously fix a "locator's" position at the instant a target is seen. These positionings become part of a flexible trilateration network composed of ground-based and airborne receiver-transmitters. To obtain line-of-sight accuracies over the horizon, airborne relays are used.

As a result of these Cubic systems, multiple weapons at remote locations can be fired at the right targets quickly.



Electronic targeting operation: Existing airborne or ground-based "locators" can already spot targets. New Cubic systems locate these "locators" with speed and pinpoint accuracy!

Proven capability...

Development of advanced targeting systems stems from Cubic's industry-leading experience in the field of electronic distance measurement. The U.S. Army's SECOR satellite surveyor and the key element of the U.S. Air Force aerial photomapping system are both recent Cubic achievements.

Electronic battlefield targeting will prove increasingly important in defense and "brushfire" warfare control. For information, write: Chief Scientist, Cubic Corporation, Dept. D-192, San Diego, Calif. 92123.

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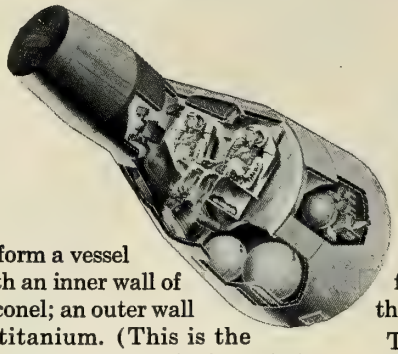
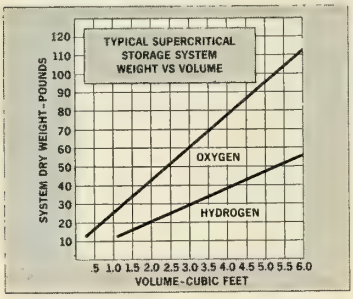
How do you contain up to six cubic feet of cryogenic fluid in space with a weight loss of only .48 pounds per day? Ask Garrett.



Many companies build cryogenic storage vessels for use on the ground.

But when it comes to life support systems for astronauts or other gas supply systems, there are unique problems which cannot be solved by everyone.



A good case in point is this: Garrett-AiResearch builds cryogenic containers for helium, nitrogen, hydrogen or oxygen that will perform with complete reliability in zero gravity. They are designed to handle all of the requirements for fuel cells, fuel tank pressurization, and environmental systems, from the time of launch through extended space mission.

Developing optimized cryogenic systems for specific applications is a Garrett-AiResearch specialty. Our scientists and technicians have been at it since 1954.

In the process we've developed some exceptional techniques.

A typical example is butt welding two 29-inch titanium hemisphere walls .037 inch thick...matching their peripheral dimensions within ±.002 inch.

Also, dissimilar metals such as titanium and Inconel are joined to form a vessel with an inner wall of Inconel; an outer wall of titanium. (This is the case for oxygen, which can't be stored in contact with titanium.)

Excellence in fabrication is just part of the story.

Garrett-AiResearch also has a quarter century of experience in all phases of heat transfer design, development and production. Garrett builds all the valves, heat exchangers and controls for complete cryogenic systems for any application.

To insure that no contamination enters the containers, one of the most advanced laminar flow clean rooms in the industry was built at AiResearch.

The result of this experience is cryogenic vessels so dependable they won't leak one standard cubic centimeter of gas into their insulating annulus in a 30-year period. (This is required to maintain the low-fluid weight loss described in the headline.)

This kind of technical perfection went into high pressure tanks used by NASA astronauts on Mercury flights. The same precision is going into supercritical storage vessels for Gemini and LEM.

Garrett-AiResearch is at work now on new approaches to storing cryogenics for even more advanced space vehicles.

Established computer programs can rapidly design optimized systems to fit the most rigid requirements. You'll find a quick solution to your cryogenic storage problem at Garrett's AiResearch Los Angeles Division because...

Garrett is experience

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ESRO I (satellite)

TYPE: Scientific

STATUS: Development

MISSION: To investigate northern polar ionosphere during winter

CONTRACTING AGENCY: European Space Research Organization

PRIME CONTRACTOR: Laboratoire Central de Télécommunications, Paris

PRINCIPAL SUBCONTRACTORS: Bell Telephone Manufacturing Co., Antwerp and Contraves AG, Zurich

CONFIGURATION: Cylindrical shape, weighing 154 lbs., with distinctive ball-like ion probe above main satellite body and two long booms connected to base of satellite. Plasma probes are housed at the ends of the two long booms. Stabilized by passive magnetic means

ORBIT: Tentatively planned for 1,500 km (930 miles) apogee; 275 km (170 miles) perigee; inclination 90 degrees

LAUNCH DATE: Late 1967 using a NASA-supplied Scout launch vehicle from Vandenberg AFB, Calif.

ESRO II (satellite)

TYPE: Scientific

STATUS: Development

MISSION: Seven on-board experiments, six supplied by British and one by French, to measure a variety of particle and proton levels

CONTRACTING AGENCY: European Space Research Organization

PRIME CONTRACTORS: Hawker Siddeley Dynamics and S.A. Engins Matra

ORBIT: Inclined 98° to equator, 90-in. period, 685-mi. apogee, 218-mi. perigee; one-year lifetime

LAUNCH DATE: ESRO II, to be launched before ESRO I, will be put into orbit from Western Test Range by NASA aboard a Scout in March, 1967

REMARKS: Satellite will include attitude-stabilization system; ESRO I and II are only two projects approved thus far by the contracting agency

Ophos IE (booster stage)

TYPE: Proposed advanced ELDO third stage

STATUS: Research and development

PRIME CONTRACTOR: Boelkow-Entwicklungen KG, West Germany

PERFORMANCE: Payload, 1,320 lbs.

CONFIGURATION: Gross design weight, 8,600 lbs.; empty, 1,150 lbs.; radial thrust chamber and E-D nozzle designed for 4,000 kp thrust; two verniers at 40 kp thrust in vacuum. High-energy propellants F_2/H_2; length, 142 in.; diameter, 79 in.

REMARKS: Mainly company financed research with moderate government research funds from High Energy Rocket Engine National Development Project; tests using LOX and subcooled H_2 already conducted

FRANCE

A-1 (satellite)

TYPE: Experimental

PROGRAM SPONSOR: CNES

REMARKS: Used for sub-orbital testing of Diamant stages

Agate (rocket)

TYPE: IRBM research rocket; forms first stage of Rubis

STATUS: Operational

RESPONSIBLE AGENCY: SEREB (Société pour l'Etude et la Réalisation d'Engins Balistiques)

CONTRACTORS: Nord Aviation, SEPR, Sud-Aviation

PERFORMANCE: Has reached 30-mi. altitude with half-ton payload

CONFIGURATION: Length, 27.8 ft.; diameter, 2.6 ft.; single stage; liftoff weight, over 3 tons

PROPULSION: Solid, 4,180 lbs., 48,400 lbs. thrust for 27 sec.

GUIDANCE: None

REMARKS: SEREB, technical IRBM agency under Délégation Ministérielle de l'Armement, is composed of representatives of Sud-Aviation, Nord Aviation, ONERA, Dassault, SNECMA, Matra and SEPR; in Precious Stones Series; others in series, Diamant, Emeraude, Rubis, Saphir and Topaze

AJ. 168/AS. 37 (Anglo-French missile)

REMARKS: See entry under Great Britain listings

AS-20 (missile)

TYPE: Air-to-surface

STATUS: Operational

PRIME CONTRACTOR: Nord Aviation

CONFIGURATION: Length, 8.5 ft.; diameter, 9.84 in.; span, 2.65 ft.; weight, 293 lbs.; solid booster and sustainer

GUIDANCE: Radio control, visual alignment, multichannel HF transmitter

AS-30 (missile)

TYPE: Air-to-surface

STATUS: Operational

PRIME CONTRACTOR: Nord Aviation

CONFIGURATION: Length, 12.5 ft.; diameter, 13.5 in.; span, 3.3 ft.; weight, 1,100 lbs.; solid booster and sustainer

GUIDANCE: Multi-channel HM transmitter

REMARKS: Chosen by Britain to arm its Canberra bombers for strike missions

Aurore (sounding rocket)

TYPE: Meteorological

STATUS: Operational

PRIME CONTRACTOR: SNECMA

PERFORMANCE: 5-kg payload to 80 km; 25 kg thrust

CONFIGURATION: 3.18 meters long, 0.12 meters dia.

REMARKS: Parachute recovery used

Bérénice (rocket)

TYPE: IRBM research

STATUS: Operational

RESPONSIBLE AGENCY: Office National d'Etudes et de Récherches Aérospatiales (ONERA) for SEREB (IRBM agency)

PERFORMANCE: Mach 12 re-entry when third and fourth stages fired in descent

CONFIGURATION: Four solid stages; length, 42 ft.; diameter: first stage, 22 in., fourth stage, 9 in.; all-up weight, 7,400 lbs.

GUIDANCE: First stage has three-axis autopilot transmitting command signals to four solid boosters attached to first stage; attitudes of third and fourth stages controlled before re-entry

INSTRUMENTATION: ONERA telemetering equipment

PROPULSION: Four solid stages and four small "guidance" solid rockets; all but fourth stage by SEPR

REMARKS: Optical ground equipment of the French Navy Launching Center (CERES) on Levant Island in Mediterranean; also ONERA and CERES electromagnetic trajectography

Bélier (sounding rocket)

STATUS: Operational

PRIME CONTRACTOR: Sud-Aviation

PERFORMANCE: 4,070 lbs. thrust 22 sec.; I_{sp}, 203 sec.; max. altitude, 50 mi.; max. velocity, 4,330 fps.; typical payload, 66 lbs. to 50 miles altitude

CONFIGURATION: Single solid booster; Jericho "epictete" propellant grain (457 lbs.); length, 13.1 ft.; all-up weight, 689 lbs.; fins house telemetry gear and responder antennas

INSTRUMENTATION: CNET and CNES

REMARKS: To be built under license in India

Centaure (sounding rocket)

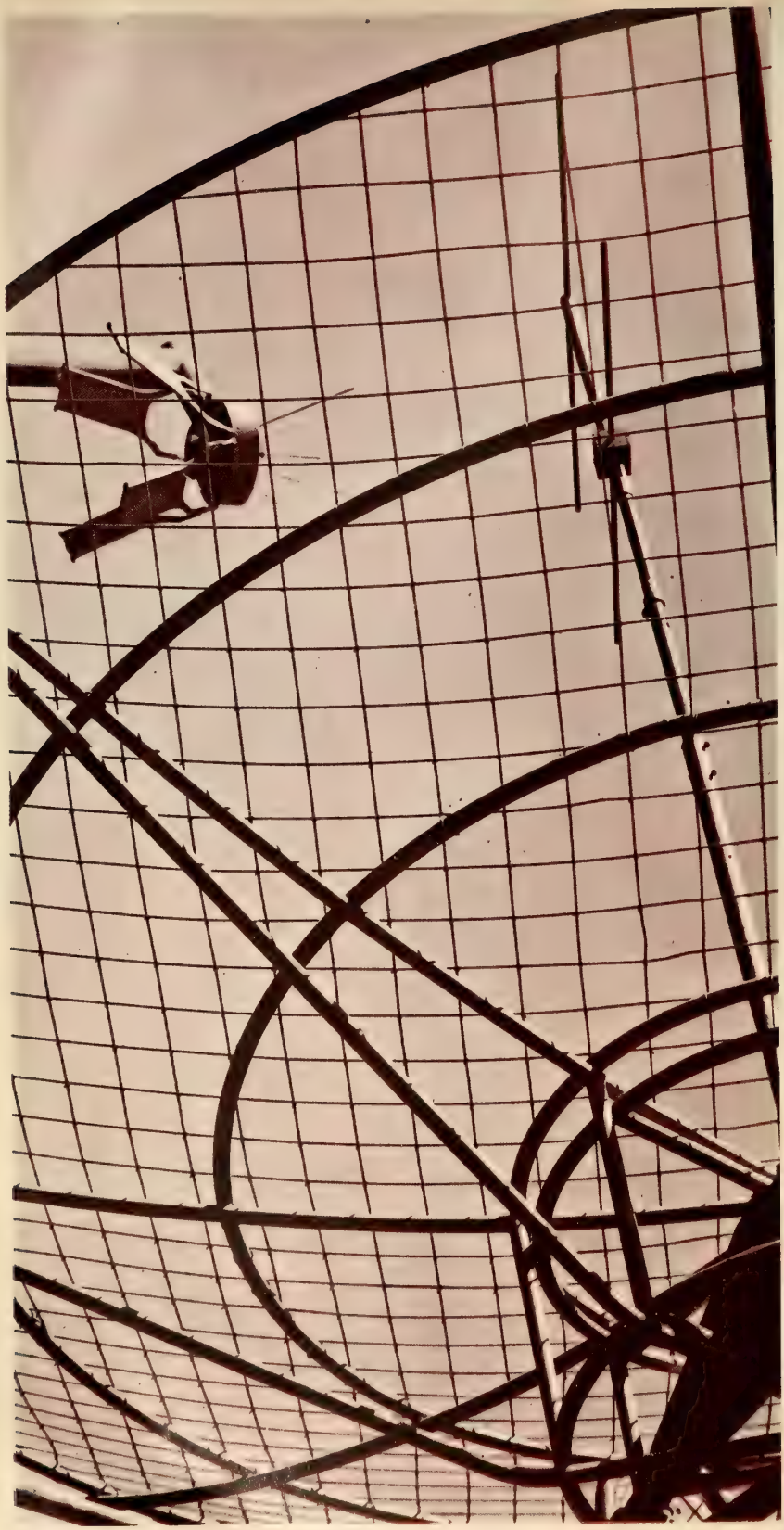
STATUS: Operational

PRIME CONTRACTOR: Sud-Aviation

PERFORMANCE: Thrust: first stage, 8,800 lbs. 4 sec.; second stage, 4,070 lbs. 22 sec.; I_{sp}: first, 200; second, 203; typical payloads, 100 lbs. with max. altitude, 110 mi.; max. velocity, 5,834 fps

CONFIGURATION: Length, 19.5 ft.; diameter: first, 9.8 in.; second, 11 in.; all-up weight, 1,080 lbs. max.; two solid stages, first-stage propellant grain is 206.8 lbs. Venus "Plastolite"; second stage is modified Bélier

REMARKS: First-stage diameter smaller than second stage; to be built under license in India; France will provide four for Indian use beforehand



D-1 (satellite)

STATUS: R&D

PROGRAM SPONSOR: CNES

CONTRACTORS: S.A. Engins Matra, frame; Dassault, electronics; C.N.R.S., solar panels; S.A.T., assembly of power-generating system

MISSION: Check reliability of French-made space equipment; to be launched by Diamant in first quarter of 1966 from Hammaguir, Algeria; period of about two hours, life expectancy, 3 months

CONFIGURATION: 40 lbs., of which 13 lbs. will be structure, panels and aerials; orbit planned is 1,800-mi. apogee and 375-mi. perigee; initial purpose is to check rotation of final stage and payload, measure separation velocity, and similar launch characteristics; 4 solar panels will be extended in orbit; shape is roughly a cylinder 19.4 in. dia., and 7.85 in. high; four telemetry antennas are on upper face, transmitting on 150 mc; dipole on lower face transmits on 400 mc; spin-stabilized at 30 rpm; orbit inclination will be 30°.

REMARKS: Flight prototype now nearing completion; satellite will also check out French capabilities in orbit determination by interferometry ground systems and Doppler effect measurements

D-2 (satellite)

STATUS: R&D

PROGRAM SPONSOR: CNES

CONFIGURATION: Structure and payload area mating now under study; weight 75 lbs., of which 20 lbs. is payload; 28 in. dia.

MISSION: First purely scientific satellite in French program; equipment will study distribution of geocoronal atomic hydrogen; primary experiment will measure absorption of the Lyman-alpha lines of atomic hydrogen by optical resonance methods developed by J. E. Blamont of CNES

PERFORMANCE: To be launched by Diamant early in 1968 from French Guiana site under development; orbit 30° to equator, 550-mi. apogee, 275-mi. perigee

REMARKS: First stabilized French satellite; single-axis stabilization will use either magnetic or gas-jet system; solar orientation to within 15 min. of arc is goal; will spin at two rpm

R/M
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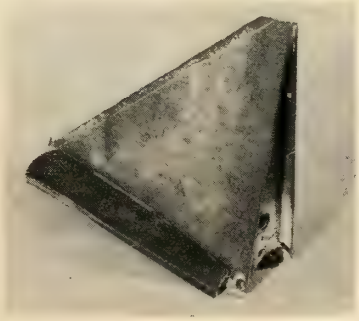

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Fig. 1 Effect of Laminating Pressures On Specific Gravity

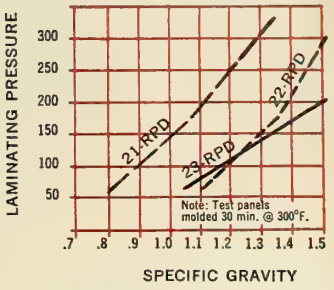

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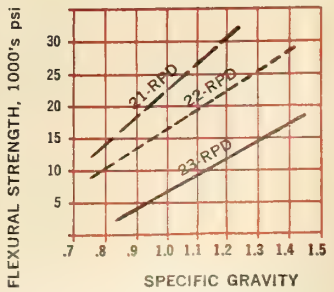
Fig. 2 Mechanical Properties of R/M Low Density Materials



meet varying needs. The graph, Fig. 2, indicates how strength varies with specific gravity for each of the basic styles of material.

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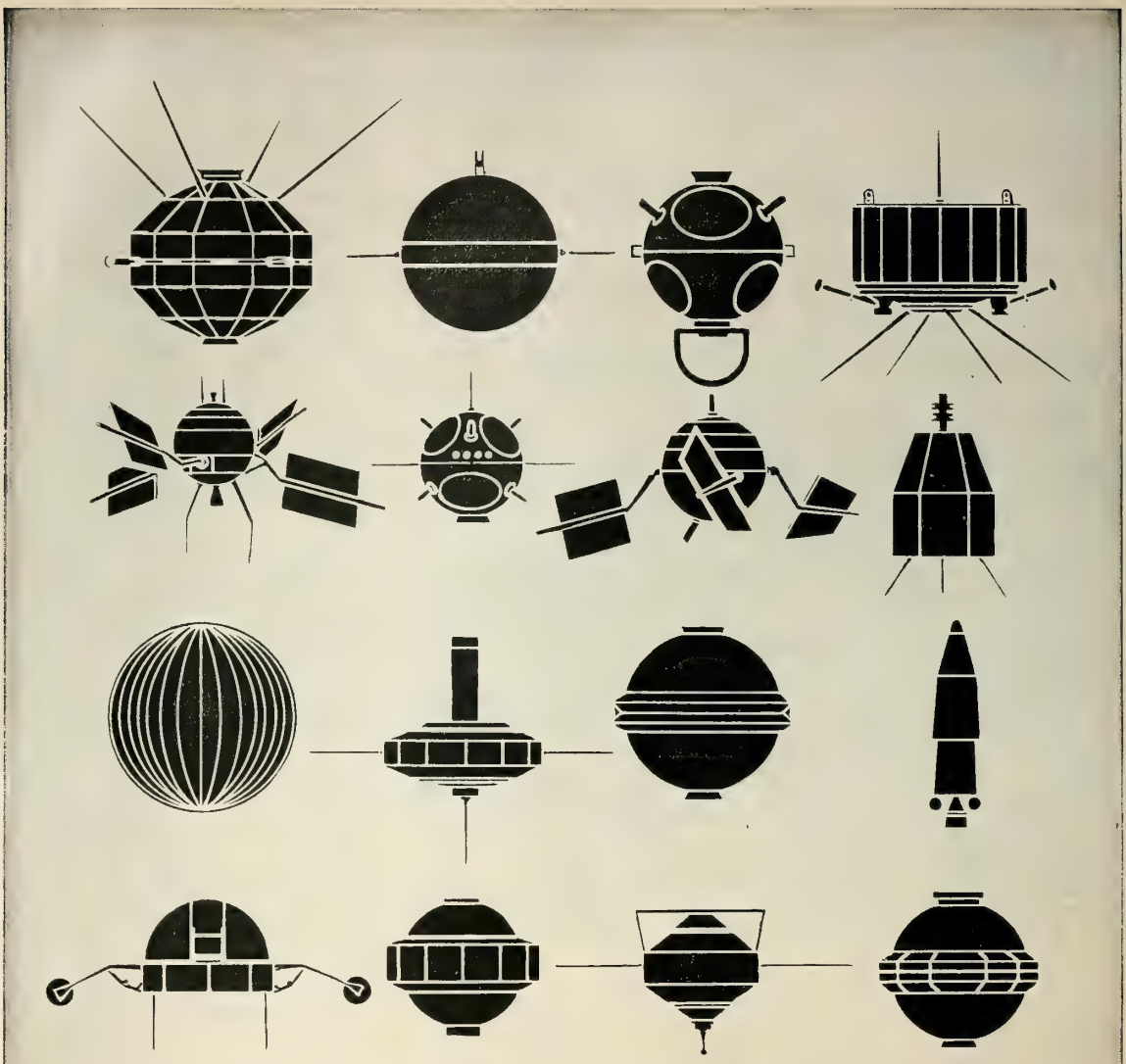

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D-3 (EOLE) (satellite)

STATUS: R&D

PROGRAM SPONSOR: CNES

MISSION: Project Eole using D-3 satellite calls for the spacecraft to query 500 or more constant-pressure balloons sent aloft around an equatorial band to gather meteorological data; this is a test of feasibility of gathering data in this fashion on a worldwide basis

REMARKS: Scheduled for a Diamant launch sometime in 1967, but program could be accelerated if NASA agrees to furnish an earlier Scout launch; could be launched in this manner before D-2

Dauphin (sounding rocket)

STATUS: R&D

PRIME CONTRACTOR: Sud-Aviation

PERFORMANCE: Max. altitude, (220-lb. payload) 85 mi., (650-lb. payload) 50 mi.

CONFIGURATION: Single solid stage; length, 16.7 ft., diameter, 2.8 ft.

Diamant (space rocket)

MISSION: French satellite launcher for national space program

STATUS: Development

RESPONSIBLE AGENCY: CNES and Délégation Ministérielle de l'Armament

CONTRACTORS: Nord Aviation, first and second stages; Sud-Aviation, third stage

TECHNICAL ADMINISTRATION: SEREB

PERFORMANCE: Expected to be able to place 80-kg payload into 400-1,200 km orbits, or smaller payloads into eccentric orbits ranging to 10,000 km

CONFIGURATION: Mk 1: liquid first stage 32.8 ft. long, has all-up weight of 31,240 lbs., with total thrust of 28 tons; spent weight, 3,740 lbs.; second stage: modified Topaze (see Topaze details); third stage: glass fiber-wound Sud-Aviation design, solid fuel, 1,430-lb. polyurethane grain burns 47 sec.; Mk 2 version may have 45.9-in.-dia. solid-grain first-stage motor developing up to 40 tons, compared to Mk 1 first-stage thrust of 28 tons; Service des Poudres has already developed and tested grains weighing 25 tons

REMARKS: Slipped to 1966; guidance problems mostly responsible; all three stages individually tested successfully in flight

Dragon (sounding rocket)

STATUS: Operational

PRIME CONTRACTOR: Sud-Aviation

PERFORMANCE: Thrust, first stage, 24,000 lbs., 16.5 sec.; second, 4,070 lbs., 22 sec.; altitude, 292 mi.; payload, 66 lbs.

CONFIGURATION: Length, 23 ft.; diameter, first, 2.8 ft.; second, 11 in.; weight, 2,926 lbs.

PROPELLANT: Two solid stages, first stage propellant grain is Stromboli "Prestolite," second stage is modified Belier

REMARKS: At least nine launched to date; super Dragon under study by Sud for CNES, aimed at increasing payload to 200 lbs.; involves larger-diameter first stage and Dragon-type second stage; is linked to Eridan program, which is also finding military application

Emeraude (space rocket)

STATUS: R&D

PRIME CONTRACTOR: SEREB

CHARACTERISTICS: Liquid first stage, dummy second and third stage; will test Diamant first-stage propulsion plus design and airframe structure for Diamant

REMARKS: In precious stones series

ENTAC (missile)

TYPE: Anti-tank

REMARKS: Prime contractor, DEFA; first-line European producer, Atelier de construction de Puteau; producer for U.S. Army, Nord Aviation; see U.S. surface-to-surface missiles

Eridan (sounding rocket)

STATUS: R&D

PRIME CONTRACTOR: Sud-Aviation

PERFORMANCE: Thrust, each stage 22,000 lbs. for 15 sec.; designed to reach 375 mi. altitude with 220-lb. payload or 187 mi. with 660 lbs.

CONFIGURATION: Two solid stages. Length, 27.2 ft.; weight, 4,466 lbs.

REMARKS: CNES version outgrowth of Dragon program; military use of this vehicle or modification indicated

FR-1 (satellite)

TYPE: Unmanned scientific

MISSION: 160-lb. magnesium satellite to measure electronic and magnetic components of ULF radio emissions from a near-polar orbit of 800 kilometers altitude

STATUS: Test

CONTRACTOR: CNES

BOOSTER: Scout

REMARKS: First French satellite; will be launched by NASA last half of 1965 aboard Diamant vehicle

HOT (missile)

TYPE: Helicopter or vehicle-mounted anti-tank missile; joint French-German project

STATUS: Advanced development

PRIME CONTRACTOR: Nord Aviation and Boelkow

PERFORMANCE: Range, 240-13,-000 ft.; speed 630 mph

CONFIGURATION: 4 ft. long, 5 in. dia.; solid propulsion; weighs 44 lbs. at launch; with tubular launcher, 55 lbs.

GUIDANCE: Visual target tracking for operator and IR homing for missiles; wire command guidance for in-flight corrections

REMARKS: Viewed as second-generation replacement for SS-11; operational 1967.

Iris (postal rocket)

TYPE: Mail carrier

STATUS: Development

PRIME CONTRACTOR: Matra

PERFORMANCE: Cruise altitude, 72,000 ft.; speed, over Mach 2; range, 435 mi.; mission time, 20 min.; payload, 66 lbs.

CONFIGURATION: Canard shape; 2 ramjets; vertically launched; rotor extends on descent and allows controlled landing like that of a helicopter with telescoping blades; liftoff weight, 2,425 lbs.

REMARKS: Landing system developed by Société Gyravions Dorand

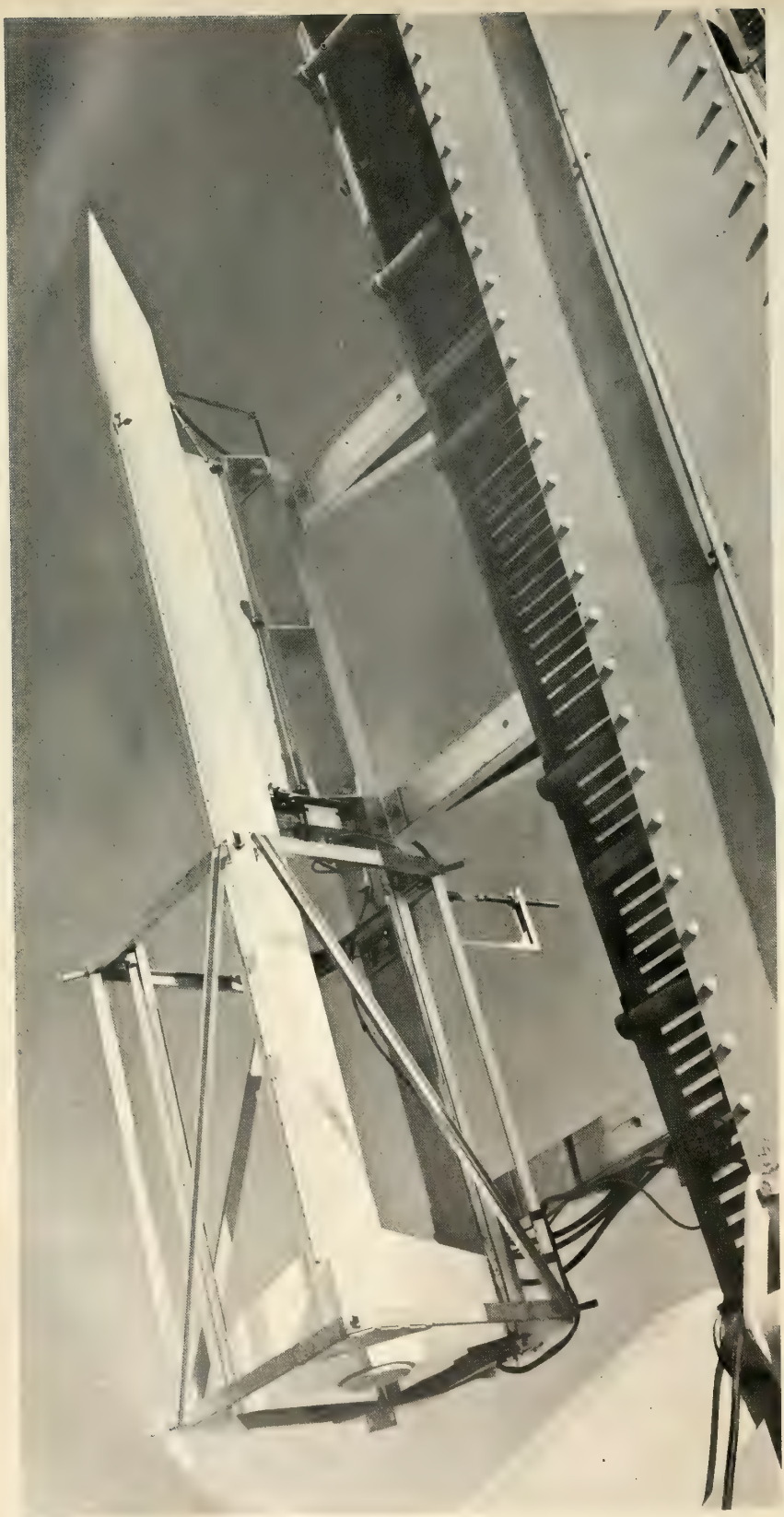
Latécoère 110 (rocket)

TYPE: Research vehicle

STATUS: R&D

PRIME CONTRACTOR: Société Industrielle d'Aviation Latécoère

REMARKS: Postal experimental vehicle developed for Ministry of Mail and Telecommunications



LEX (research rocket)

TYPE: Experimental vehicle for hybrid propulsion

STATUS: R&D

CONTRACTOR: ONERA

PERFORMANCE: Carries 10 lbs. to 60-mi. altitude

CONFIGURATION: Length, 11 ft.; diameter, 6 in.; weight, 170 lbs.

PROPULSION: Single hybrid rocket with thrust varying from 2,200 to 440 lbs. for optimum economy of impulse; variation obtained by free expansion of pressurizing gas

REMARKS: Could be used as a meteorological sounding rocket

Malafon (missile)

TYPE: Anti-submarine

STATUS: Operational

MISSILE PRIME CONTRACTOR: Société Latécoère

PERFORMANCE: Range, over 14,000 yds.; velocity, 754.4 fps

CONFIGURATION: Twin solid boosters; carries ASW homing torpedo; overall length, 19.7 ft.; all-up weight, 3,179 lbs.

GUIDANCE: Radio control

TECHNICAL ADMINISTRATION: Service Technique des Constructions et Armes Navales

REMARKS: First sea test in 1962; will arm frigates now under construction and T.47 class escort vessel

Masurca (missile)

TYPE: Ship-to-air

STATUS: Development

PERFORMANCE: Mk 2 Mod 2, 20 mi.; Mk 2 mod 3, 25 mi.; velocity, over 2,500 fps

CONFIGURATION: Two stages; length, 27.9 ft.; weight, 3,828 lbs.; solid booster and sustainer

GUIDANCE: Mk 2 Mod 2, beam rider; Mk 2 Mod 3, beam rider and semiactive homing

RADAR/RADIO CONTROL: Société Française Thomson-Houston

FIRE CONTROL: IBM France

TECHNICAL ADMINISTRATION: Service Techniques des Constructions et Armes Navales

LAUNCHING AND HANDLING: Etablissement Industriel de la Marine Nationale à Ruelle

REMARKS: Mk 1 in production and destined for early available missile frigates; Mk 2 will arm Duquesne- and Suffern-class frigates, helicopter carrier La Résolue and future frigates

LEX

Matra R. 511 (missile)

TYPE: Air-to-air

STATUS: Operational

PRIME CONTRACTOR: Société des Engins Matra

PERFORMANCE: Range, 9,800 to 59,000 ft.

CONFIGURATION: Length, 10.14 ft.; diameter, 8.5 inches; span 3.3 ft.; weight, 396 lbs.; single-plane wings and dorsal rear fin, with vertical stabilizers at wing-tips

GUIDANCE: Compagnie Française Thomson-Houston; system, semi-active radar

PROPULSION: Solid fuel by Hotchkiss-Brandt

Matra R. 530 (missile)

TYPE: Air-to-air

STATUS: Operational

PRIME CONTRACTOR: Société des Engins Matra

PERFORMANCE: Sea level to 82,000 ft. operating altitude; range 13 mi.

CONFIGURATION: Length, 10.5 ft.; diameter, 8.5 in.; weight, 429 lbs.; fin span, 36.1 in.; two sets of cruciform fins

GUIDANCE: Version A, semiactive radar homing system by G. A. M. Dassault; version B, infrared homing by Société Anonyme de Télécommunications

PROPULSION: Solid rocket with boost/sustain phases; 18,560 lbs. total impulse

OTHER SYSTEM SUBCONTRACTORS: Hotchkiss-Brandt, Compagnie Générale de Télégraphie Sans Fil, and Télécommunications Radioélectriques et Téléphoniques

REMARKS: Witnesses to flight tests described R. 530 as "queen" of air-launched missile armament; trials reported highly successful; ordered by Australia to equip its Mirage III fighters, and will be used on French Navy "Crusaders"

Milan (missile)

TYPE: Infantry anti-tank weapon, similar to HOT; joint French/German project

STATUS: Advanced development

PRIME CONTRACTORS: Nord Aviation and Boelkow

PERFORMANCE: Range, 240-6,500 ft.; speed 400 mph

CONFIGURATION: 2-ft. 3-in. long, 3-in. dia.; weighs 22 lbs. including 9-lb. launch tube; also has 11-lb. launch and control unit

GUIDANCE: Similar to HOT, but designed to be fired from shoulder or tripod by one man

REMARKS: Aimed at replacement market for ENTAC and Cobra anti-tank missiles; operational 1967

Roland (missile)

TYPE: Surface-to-air; joint French/German project

MISSION: Field army air-defense weapon for intercepting low-flying targets below Mach 1.3, fair weather only

STATUS: Development

PRIME CONTRACTORS: Nord Aviation and Boelkow

PERFORMANCE: Effective range, 1,650 ft. to 3.2 n. mi.; top speed, Mach 2

GUIDANCE: Launch unit mounted on tracked vehicle includes search and surveillance radar with 8.1-mi. range, optical target sight, IR tracking system and a small computer; radio command link positions jet vanes aboard the missile in flight

CONFIGURATION: 8 ft. long, 6 in. dia., weighs 140 lbs.; launched from 22-lb. plastic storage and launch tube; automatic load system aboard vehicle

REMARKS: Expected operational 1968

Rubis (rocket)

TYPE: Development of Diamant satellite launch vehicle; scientific experiments

STATUS: Operational

RESPONSIBLE AGENCY: SEREB

CONTRACTORS: First stage, Nord Aviation, Sud-Aviation, SEPR; second stage, Sud-Aviation for structure, Matra for payload capsule

CONFIGURATION: Overall length, 31.7 ft.; diameters, 2.6 ft. and 2.1 ft.; fin-stabilized; steel first stage, glass fiber second stage; second stage empty weight, 1,606 lbs.; loaded weight, 3,036 lbs.; first stage empty weight, 1,485 lbs.; loaded weight, 5,665 lbs.; total launch weight, 7,470 lbs.

PERFORMANCE: Capable of lifting 110-lb. payload to 1,250-mi. altitude as probe; principal function is to serve as development vehicle for Diamant satellite launcher

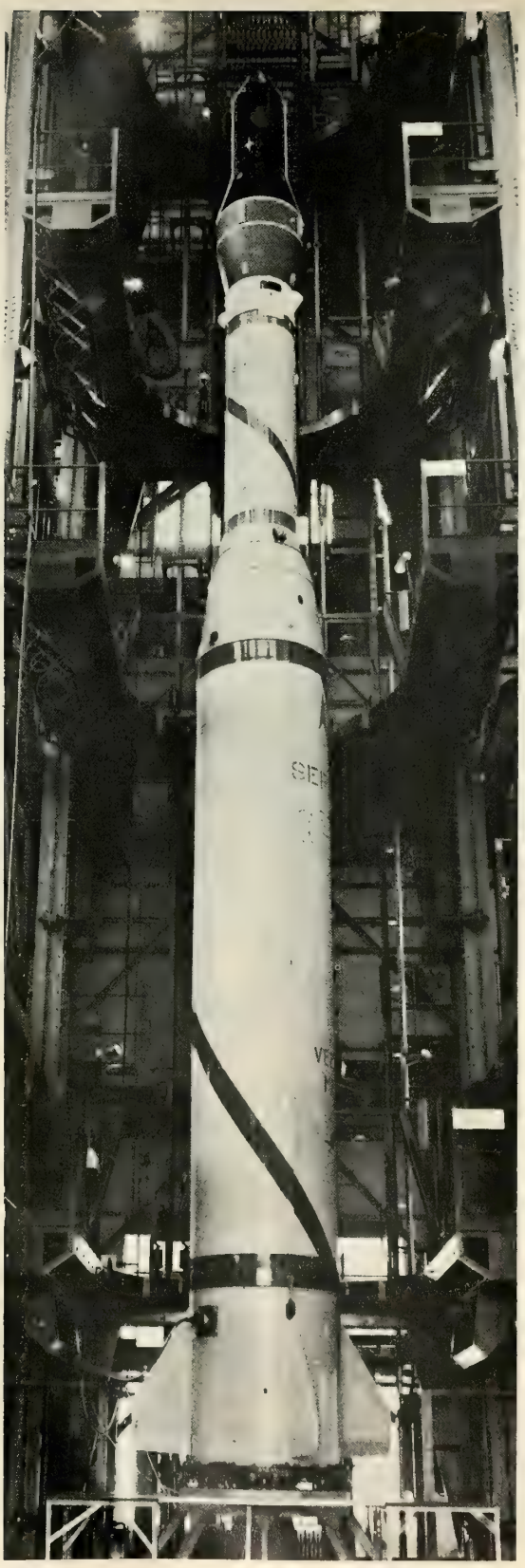
PROPULSION: Solid propellants; first stage uses 4,180 lbs.; second stage uses 1,430 lbs.; first stage burns 27 seconds with 48,400 lbs. thrust; second stage burns 46 seconds with 11,000 lbs. thrust at specific impulse of 275 seconds

GUIDANCE: Ramp-launched with corrections included in angle and azimuth arm

REMARKS: Second stage of Rubis is similar to third stage of Diamant; series of six trial firings successfully completed; first operational CNES launch June 3, 1965, with D-1 satellite on sub-orbital flight; first scientific payload for CNES to be launched September, 1965

R. 530

MILAN



SAPHIR

Saphir (space rocket)

STATUS: Operational

PRIME CONTRACTOR: SEREB

CHARACTERISTICS: Liquid first stage; solid second stage; dummy third stage; follows Emeraude in proving Diamant design

GUIDANCE: Probably modified Topaze system

REMARKS: In Precious Stones series; will provide re-entry and flight dynamics data vital to French military surface-to-surface missile program; first firing occurred July, 1964

SS-10 (missile)

TYPE: Anti-tank

REMARKS: See U. S. surface-to-surface missiles

SS-11 (missile)

TYPE: Anti-tank

REMARKS: See U. S. surface-to-surface missiles

SS-12; AS-12 (missile)

TYPE: SS, anti-tank; AS, air-to-surface

STATUS: Operational

PRIME CONTRACTOR: Nord Aviation

PERFORMANCE: Surface launch max. range, 6,550 yds.; air launch max. range, 11,000 yds.; spin-stabilized

CONFIGURATION: Length, 73 in.; diameter, 7.1 in.; weight, 165 lbs.

SSBS (missiles)

TYPE: Strategic ballistic missile

STATUS: Development

CONFIGURATION: First stage reported 1.5 meter dia., 42 tons thrust through four movable nozzles; solid, holding 10 tons propellant; second stage same diameter

REMARKS: First stage is believed to have completed ground static firings and will soon be flight tested

Tacite (sounding rocket)

TYPE: Infrared horizon scanner

STATUS: R&D

PRIME CONTRACTOR: ONERA for CNES

PROPULSION: Single solid booster

PERFORMANCE: Carries 450-lb. instrument capsule to 135-mi. altitude

GUIDANCE: Nose cone stabilized vertically, spinning slowly

CONFIGURATION: Length, 22.2 ft.; diameter, 22 in.; weight, 4,150 lbs.

REMARKS: First launched June 15, 1965; will be used to carry instruments to study infrared region of upper atmosphere

Topaze (rocket)

TYPE: IRBM research vehicle and Diamant second-stage prototype

STATUS: Flight testing

PRIME CONTRACTOR: SEREB

CHARACTERISTICS: First stage: Nord-designed rocket plant using four SEPR motors and power pack by Air-Equipement; this stage constitutes booster; second stage: Nord-designed rocket plant; 30-in. polyurethane grain weighs 5,005 lbs.; burns 42 sec.; up to 30,000 lbs. thrust in vacuum; flight control by swivel nozzles; autopilot guidance by S.A.G.E.M.; interstage and equipment section by Sud-Aviation; SEFI automatic checkout system

REMARKS: Diamant will use modified Topaze as second stage; prototype Diamant third stage was given compatibility flight test with Topaze and recovered by parachute in test at Hammaguir; propellant grain manufactured by La Pouderie de St.-Médard; in Precious Stones series

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Véronique 61 (sounding rocket)

TYPE: Research probe
STATUS: Development
PRIME CONTRACTOR: Laboratoire de Récherches Balistiques et Aerodynamiques pour l'Armament
PERFORMANCE: Reached 161.5 mi. altitude in first firings
CONFIGURATION: Single stage, liquid propellant
REMARKS: Designed to replace Véronique probe and gets 62 mi. higher; first flights were in June, 1964; development is through Ministry of Defense and firings are at Hammaguir, Algeria

Vesta (sounding rocket)

STATUS: R&D flight test
PRIME CONTRACTOR: D.E.F.A., Laboratoire de Récherches Balistiques et Aérodynamiques (Vernon)
PERFORMANCE: 1,100-lb. payload to 236 mi.; five times early Véronique payload area
CONFIGURATION: Length, 32.5 ft.; diameter, 32.8 in.; all-up weight, 11,979 lbs.; total surface thrust, 31,680 lbs.; I_{sp} at surface, 193 sec., in vacuum, 238 sec.
REMARKS: Vesta is higher performer than Véronique 61 or 61A; to be used for carrying monkeys into space for biomedical research on motor nerves under zero-g conditions

GERMANY

Cobra 810 (missile)

TYPE: Anti-tank
STATUS: Operational with West German Army; Denmark and Italy have ordered
PRIME CONTRACTOR: Boelkow-Entwicklungen KG
PERFORMANCE: Range, 437 to 1,750 yds. at about 190 mph
CONFIGURATION: Length, 38 in.; span, 3.9 in.; launch weight 23.3 lbs.
GUIDANCE: Wire-guided, rolling stability acceleration guidance
REMARKS: Top feature: ease of one-man handling

HOT (French/German missile)

REMARKS: See entry under French listings

Milan (French/German missile)

REMARKS: See entry under French listings

Project 621 (sounding rocket)

TYPE: Recoverable
STATUS: Development
PRIME CONTRACTOR: Dornier System GmbH; also recent funding to Boelkow
MISSION: Government-sponsored program to develop fully recoverable sounding rocket, i.e., booster and payload
CONFIGURATION: Dornier uses Rogallo-wing type of paraglider; 5.2 m. long, 0.3-meter-diameter booster; unit weighs 400 lbs. at launch; re-entry weight, 152 lbs.; booster liquid-fueled, develops 2.5 tons thrust; Boelkow uses fixed-wing system
REMARKS: Dornier has had major funding; Telefunken building ground-control system

Project 625 (satellite series)

STATUS: Funded studies only; government approval of first satellite, 625/A1, expected this fall
MISSION: Projected series of satellites based on U.S. Scout launchers and later on ELDO boosters; A series is small research type, B series much larger
PERFORMANCE: A-1 satellite would be placed in orbit with 3,160-km apogee, 250-km perigee, inclined 102° to equator, 120-min. period
REMARKS: A series expected to fly 2-3 years after contract signed; satellite would weigh 60-kg, be magnetically stabilized; studies completed on both series but only first of A series apt to get project approval soon; development to cost about $12 million; B series, originally intended as scientific satellite, recently shifted to technology satellite

Roland (French/German missile)

REMARKS: See entry under French listings

GREAT BRITAIN

AJ. 168/AS. 37 (missile)

TYPE: Air-to-surface, joint Anglo-French project
STATUS: Development
PRIME CONTRACTORS: Hawker Siddeley Dynamics (AJ. 168) and Engins Matra (AS. 37) for British and French governments
GUIDANCE: Expected to be highly accurate against ground targets and ships, missiles will have alternate forms of guidance; in the U.K., Marconi is developing a TV guidance system, and in France, EMD is responsible for a radar system
REMARKS: Missile is said to be suitable for installation in tactical strike and maritime reconnaissance aircraft; probably operational 1968-69

Black Knight (ballistic rocket)

TYPE: Research vehicle
STATUS: Production
PRIME CONTRACTORS: Saunders Roe, vehicle; Bristol-Siddeley, engines
CONFIGURATION: Overall length, 39 ft.; diameter, 36 in.; total fueled weight, 1,300-1,400 lbs.
PROPULSION: Single stage, liquid propellant—kerosene and HT peroxide
GUIDANCE: Simple autopilot and radio command
REMARKS: Has had 19 successful launches

Bloodhound (missile)

TYPE: Surface-to-air
STATUS: Mk 1 phasing out with RAF; Mk 2 operational in U.K. and Far East
PRIME CONTRACTOR: British Aircraft Corp. (BAC) with Ferranti Ltd.
PERFORMANCE: Mk 1, high-altitude, long-range; Mk 2, same with faster reaction and low-altitude capability and air transportability
CONFIGURATION: Mk 1, four solid boosters with two ramjet sustainers, moving wing, twist and steer
GUIDANCE: Mk 1, pulse radar semi-active homing; Mk 2, CW radar semi-active homing
OTHER CONTRACTORS: Supporting BAC and Ferranti are Associated Electrical Industries Limited, Bristol Siddeley Engines Limited, Electrical and M.L. Aviation, Ltd.
REMARKS: Mk 1 units in U.K., Sweden and Australia; Switzerland has adopted Mk 2 system for air defense; Mk 2 deployed to Malaysia; Mk 2 has Thor ramjet engine and improved countermeasures capability

Blue Steel (missile)

TYPE: Air-to-surface
STATUS: Operational
PRIME CONTRACTOR: Hawker Siddeley Dynamics
CONFIGURATION: Length, 35 ft.; max. diameter 4 ft. 2¼ in.; span, 13 ft.
GUIDANCE: Autopilot and inertial navigator, Elliott Bros., Ltd.
PROPULSION: H.T.P. and kerosene stentor engine by Bristol Siddeley Engines, Ltd.
REMARKS: Operational on Vulcan and Victor bombers, with all aircraft slated for fitting to be equipped this year

ET 316 (missile)

TYPE: Low-cost surface-to-air
STATUS: Development, successfully fired
PRIME CONTRACTOR: British Aircraft Corp.
REMARKS: Reported to be a very simple, fair-weather-only air-defense system, using TV guidance and visual target tracking

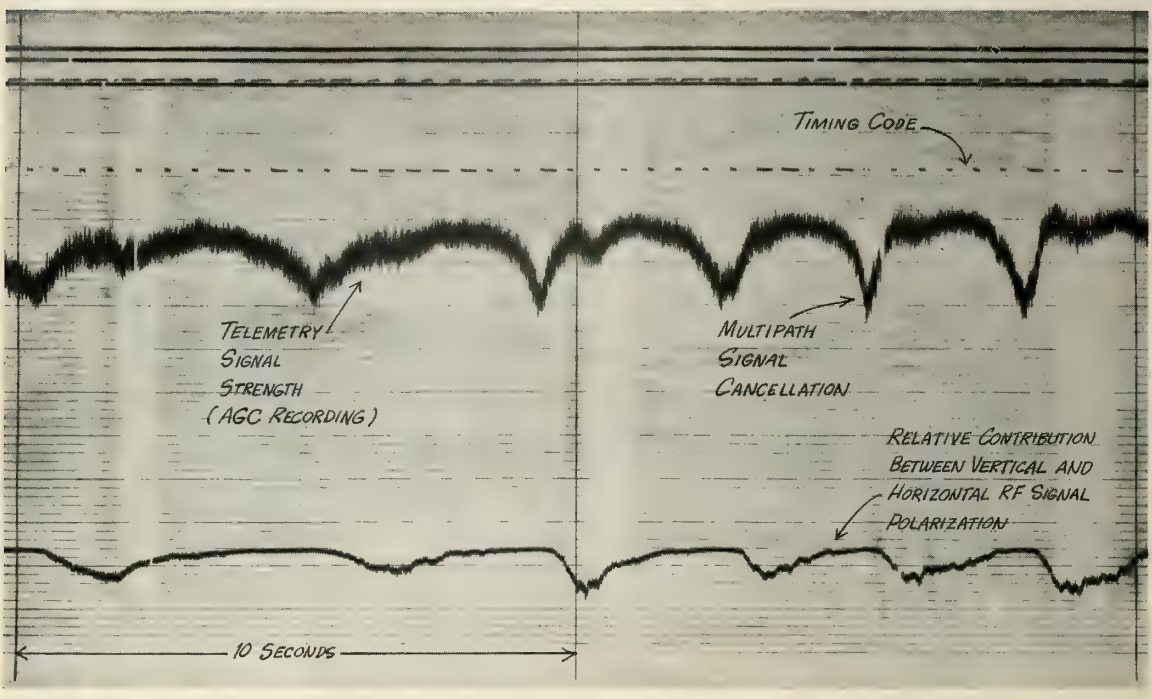
Firestreak (missile)

TYPE: Air-to-air
STATUS: Operational
PRIME CONTRACTOR: Hawker Siddeley Dynamics
PERFORMANCE: 85% success in acceptance trials
GUIDANCE: Infrared-homing, radar-slaving

Jaguar (rocket)

TYPE: Research
STATUS: Operational
PRIME CONTRACTOR: Royal Aircraft Establishment jointly with Weapons Research Establishment in Australia
REMARKS: For details, see Jabiru rocket, Australia section; 17 have been fired by British at Woomera

GEMINI 4: as seen by the


TIMING CODE
TELEMETRY SIGNAL STRENGTH (AGC RECORDING)
MULTIPATH SIGNAL CANCELLATION
RELATIVE CONTRIBUTION BETWEEN VERTICAL AND HORIZONTAL RF SIGNAL POLARIZATION
10 SECONDS

This Visicorder record shows the two parameters measured as Gemini 4 headed into its first orbit. The trace near the center of the record represents variations in the telemetry signal strength caused by multipath interference. The trace at the bottom of the record plots the relative contribution of the vertically and horizontally polarized components of the RF signal. The outputs of both components were combined in one signal and recorded on the Visicorder.

Honeywell instruments monitor performance of new airborne tracking system during historic space flight.

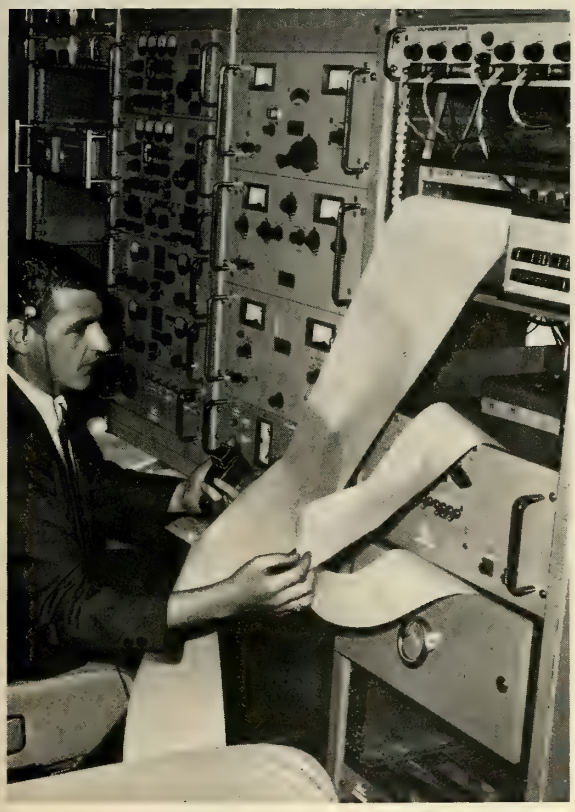
The behavior of telemetry signals received by a NASA experimental tracking plane during the recent Gemini 4 space flight was the responsibility of engineers at NASA/Goddard Space Flight Center.

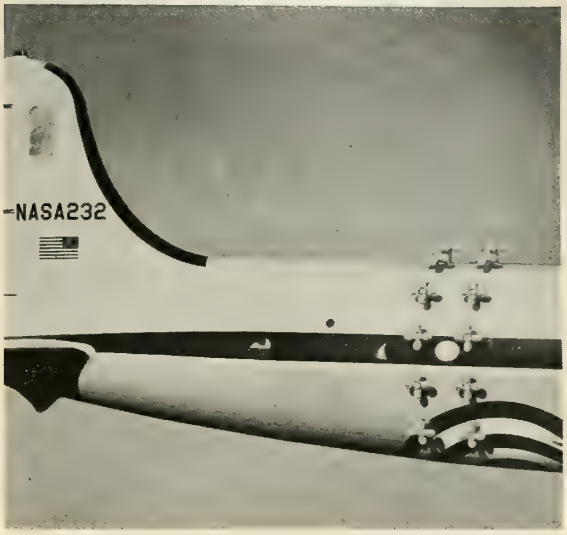
Of particular interest was the performance of a newly developed, highly sensitive airborne antenna system aboard the instrumented aircraft flying a tracking and telemetry recording mission off Cape Hatteras, N.C.

The antenna system consisted of two rows

Circle No. 23 on Subscriber Service Card

Honeywell Visicorder Oscillograph





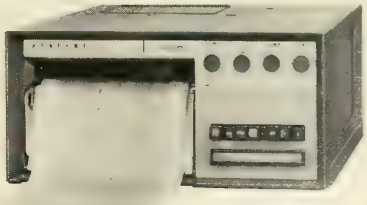
of six crossed dipole elements mounted on the right side of the aircraft. Each grouping of four antennas had a beamwidth of 35°, and tracking was successfully accomplished by beam switching as the spacecraft's elevation changed in relation to the plane.

Two Honeywell Visicorder direct-recording oscillographs enabled NASA engineers aboard the tracking plane to monitor characteristics of the telemetry signals *as they occurred.*

As a result of signal analysis by the Visicorders, NASA engineers have already been able to reshape the antenna beam and minimize its susceptibility to multipath interference.

When you need immediate readout of high frequency (up to 13,000 cps) signals for both on-line and off-line testing, investigate the Honeywell Visicorder Oscillograph. Several models in several price ranges offer paper speeds up to 160 inches per second, writing speeds in excess of 50,000 ips and as many as 36 channels of simultaneously recorded data.

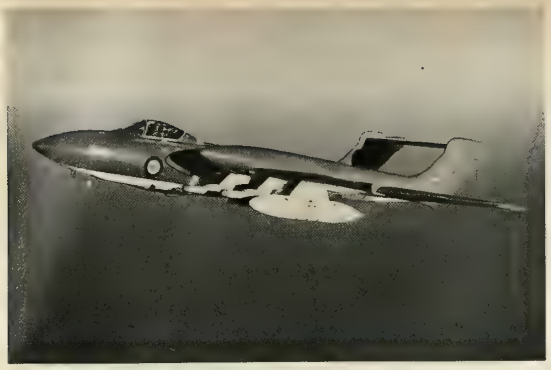
To find out how a Visicorder can help make your test easier, more efficient and more reliable, call your nearby Honeywell scientific field representative, or write Honeywell, Denver Division, Denver, Colorado 80217. Sales and service in all principal cities of the world.

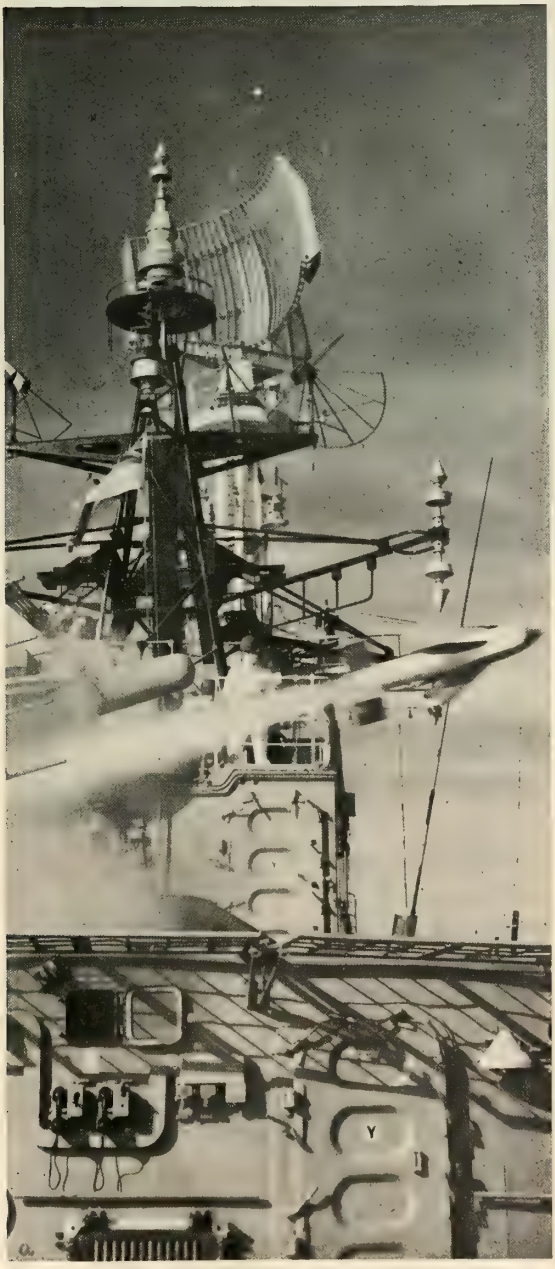


DATA HANDLING SYSTEMS

Honeywell

Circle No. 23 on Subscriber Service Card





Red Top (missile)

TYPE: Air-to-air

STATUS: Operational

PRIME CONTRACTOR: Hawker Siddeley Dynamics; Hughes, guidance

PERFORMANCE: Better range, speed, altitude and attack angle than Firestreak

CONFIGURATION: Length, 137.5 in.; dia., 8.75 in.; span, 35.7 in.; retains Firestreak design for four fixed wings and four moving rear control surfaces; also solid fuel

GUIDANCE: Infrared-homing, automatic firing upon pilot's commital release

REMARKS: Has printed circuit boards; automatic soldering used in production; arms Lightning and Vixon aircraft, deliveries beginning this year

Seacat (missile)

TYPE: Short-range ship-to-air defense

STATUS: Operational with five navies; ordered by five more

PRIME CONTRACTOR: Short Brothers & Harland Ltd.

PERFORMANCE: Subsonic "infighter" of extremely simple design; has lowest minimum range of any surface-to-air missile and good surface-to-surface potential

CONFIGURATION: Length, 58 in.; 7.5 in. dia.; 4 swept-back 60-deg. movable fins forward and 4 fixed fins aft

GUIDANCE: Radio command/optically coordinated; bulk of system remains on ship; flares on fins give visual aid for operator tracking

PROPULSION: Imperial Metal Industries solid rocket with boost/sustainer phases using integral steel case

LAUNCHER: Rose Brothers

REMARKS: New Zealand, West Germany, Chile, The Netherlands, Brazil, Australia and Sweden already ordered system, others interested; Dutch fire control by Signaalapparaten used with missile in a number of these navies; entered service in record time four years after development began

Sea Dart (CF. 299) (missile)

TYPE: Ship-to-air

STATUS: R&D

PRIME CONTRACTOR: Hawker Siddeley Dynamics

PROPULSION: Uses Odin ramjet sustainer engines for maximum range maneuverability against low- and high-flying evasive targets

PERFORMANCE: Maximum range believed to be greater than 20 mi. against high fliers, 10 mi. against low fliers; probably uses semi-active radar guidance

SUBCONTRACTORS: Associated Electrical Industries Ltd., EMI Electronics Ltd., Ferranti Ltd., G.E.C. (Electronics) Limited, Sperry Gyroscope Company Limited, Vickers-Armstrongs (Engineers) Ltd., Bristol Siddeley Engines, N.V. Hollandse Signaalapparaten

REMARKS: Intended for use on small vessels; would provide frigates with firepower comparable to 5,000-ton guided missile ships now in service and is expected to be as effective as large missiles like Seaslug, while occupying much less space; land-based version under company study for possible sale to NATO

Seaslug (missile)

TYPE: Ship-to-air

STATUS: Mk 1 operational, Mk 2 R&D

PRIME CONTRACTOR: Hawker Siddeley Dynamics (Whitworth Gloster Aircraft, Ltd.)

PERFORMANCE: Long-range ship's defense; Mk 1 on county-class guided missile ships; Mk 2 to be retrofitted

CONFIGURATION: Mk 1: length 19.8 ft.; span 4.8 ft.; dia., 16.1 in.; four solid boosters and solid sustainer

GUIDANCE: Beam-riding, General Electric Co., Ltd.

FLIGHT CONTROLS: Sperry Gyroscope Co., Ltd.

Skua (sounding rocket)

TYPE: Meteorological

PRIME CONTRACTOR: Bristol Aerojet, Ltd.

PERFORMANCE: Five-in.-dia. rocket now widely used for wind and temperature measurements to 40-mi. altitudes; a 7.5-in.-dia. version under development expected to extend capabilities to lifting 30-lb. payloads to 80 mi.; first flight trials of 7.5-in. system to be held February, 1966

RED TOP

SEACAT

Skylark (sounding rocket)

TYPE: Space research vehicle

STATUS: Operational

PRIME CONTRACTORS: RAE Farnborough, design authority and integration; BAC, airframe; Elliott-Automation, three-axis stabilization system

REMARKS: Highly successful and widely used rocket, current mainstay of U.K. research effort; first three flights of new stabilized payload version also highly successful; unstabilized version has flown more than 100 times successfully; current Skylark is Sun-oriented; work on Moon- and star-pointing versions under development

Swingfire (missile)

TYPE: Anti-tank

STATUS: R&D

PRIME CONTRACTOR: British Aircraft Corp.

REMARKS: Described as second-generation antitank missile; command controlled, wire-guided; solid-propellant missile maneuvered by jet deflection; missile launched from behind cover; fixed launch angle; no traversing or elevating of launcher necessary

Thunderbird (missile)

TYPE: Surface-to-air, mobile

STATUS: Mk 1, operational, Army; Mk 2, operational soon

PRIME CONTRACTOR: British Aircraft Corp.

CONFIGURATION: Mk 1: length, 20.8 ft., dia., 21 in., span, 64 in.; Mk 2: length, 20.9 ft, other principal dimensions same; four fixed wings; controlled by four cruciform rear fins

PROPULSION: Solid sustainer with four booster strap-on solid motors

GUIDANCE: Mk 1: pulse radar semi-active homing; Mk 2: CW radar semi-active homing

REMARKS: Mk 2 designed to be more automatic, have longer range; low-altitude capability, improved mobility and air portability;; Mk 1 deployed in Germany; Mk 2 system competing with U.S. Hawk for sale to Saudi Arabia

Tigercat (missile)

TYPE: Short-range ground-to-air

STATUS: Evaluation by R.A.F.

PRIME CONTRACTOR: Short Brothers & Harland Ltd.

PERFORMANCE: Subsonic short-range

CONFIGURATION: Same as Seacat

REMARKS: Used in conjunction with anti-aircraft guns and fire unts; said to provide greatly increased performance against low-level attack

Vigilant (missile)

TYPE: Anti-tank

STATUS: Operational

PRIME CONTRACTOR: British Aircraft Corp.

PERFORMANCE: Range: 200 to 1,800 yds., penetrates 22-in. armor plate; speed, 350 mph

CONFIGURATION: Length, 36 in.; dia., 5.16 in.; span, 11 in.; weight, 32.5 lbs.; light alloy and plastic airframe

GUIDANCE: Wire

PROPULSION: Solid

REMARKS: British, Finnish, Kuwait and Saudi Arabian armies have Vigilant units

TIGERCAT

VIGILANT

ISRAEL

Shavit Shtayem (Meteor II) (rocket)

TYPE: Meteorological research
STATUS: Development
PERFORMANCE: Only public flight test reached 48-mi. altitude
CONFIGURATION: Two-stage, solid propellant

ITALY

Meteo I, II and III (sounding rocket)

STATUS: Experimental tests
PRIME CONTRACTOR: Bombrini Parodi-Delfino
PERFORMANCE: Meteo I, 12-lb. payload to 43 mi. Meteo II, 25-lb. payload to 62 mi.; Meteo III, 25-lb. payload to 95 mi.; max. diameter, Mk. III, 21 in.
CONFIGURATION: Each two stage; Meteo II overall length, about 8 ft.; diameter, 3.95 and 6.3 in. Mk I, length 5.6 ft.; dia., 2.75 and 6.3 in.; all with cruciform fixed fins at base of each stage.

Mosquito (missile)

TYPE: Anti-tank
STATUS: Operational
PRIME CONTRACTOR: Contraves Italiana
REMARKS: Joint production with Swiss Contraves (See details under Switzerland)

San Marco (satellite)

TYPE: Scientific
STATUS: R&D
MISSION: Approximately 250-lb. satellite to measure aerodynamic drag in an equatorial orbit; will also make ionosphere propagation studies using a beacon
CONTRACTOR: Italian Space Commission
BOOSTER: Scout
REMARKS: Launched successfully Dec. 15, 1964, by Italian launch team from Wallops Island, Va.; Italians will launch the satellite from its off-shore launch platform off the coast of Kenya, Africa, in 1966 or 1967; orbit will be near-circular of 250- to 300-kilometers altitude

JAPAN

Mu Series (satellite)

TYPE: Multi-purpose
STATUS: Early R&D
PERFORMANCE: Expected to begin with small payloads and experiments which do not duplicate other worldwide efforts
REMARKS: Five-year plan to have first Japanese satellite in orbit by 1968-69, using solid propellant booster, begun this year; program to cost 37 billion yen; Mu series rockets with first-stage diameter of 4.6 ft. to be used; launchings will be from Kagoshima Space Center on Kyushu

Mat I (missile)

TYPE: Anti-tank
STATUS: Operational
PRIME CONTRACTOR: Kawasaki Aircraft Co., Ltd. (Gifu Seisakusho)
CONFIGURATION: Length, 43.5 in.; dia., 4.5 in.; span, 20.5 in.; four tail-mounted fins
GUIDANCE: Wire

Kappa Series (sounding rockets)

STATUS: Operational
PRIME CONTRACTOR: C. Itoh & Co., Ltd.
TYPES: K-6, K-6H, K-8L, K-8, K-9L, K-9M
STAGES: All solid, all two-stage vehicles except K-9L, which is three
CONFIGURATION: Length (corresponding to above sequence), 5.6 meters, 6.9, 7.4, 10.9, 12.5, 11.5; first-stage diameter: 0.15 meter, 0.15, 0.16, 0.25, 0.165, 0.25; total weight: 270 kg, 330 kg, 350 kg, 1,500 kg, 1,550 kg, 1,500 kg
PERFORMANCE: K-6, 20 kg to 60 km; K-6H, 20 kg to 80 km; K-8L, 25 kg to 160 km; K-8, 50 kg to 200 km; K-9L, 15 kg to 350 km; K-9M, 50 kg to 350 km

Lambda Series (sounding rockets)

STATUS: Flight-testing
PRIME CONTRACTOR: National Space Activities Council and Institute of Industrial Science, University of Tokyo

CONFIGURATION:	Lambda I	Lambda II	Lambda III	Lambda IV
Length	32.8 ft.	49.2 ft.	59.0 ft.	59.0 ft.
Weight	4.6 tons	5.7 tons	6.0 tons	6.0 tons
PERFORMANCE:				
Max. velocity fps.	6,232	8,209.8	10,824	15,744
Max. altitude miles (80 deg.)	49.7	211.1	310.5	931.5
Payload (lbs.)	1,100	220	110	22

SUBCONTRACTORS: Radio Research Laboratories; Yokogawa Electric Co., Ltd.; Riken Institute; Nippon-Electric Co., Ltd., Meiseri-Electric Co., Ltd.; Fuji-Precision-Machinery Co., Ltd.

LS-A (sounding rocket)

STATUS: Development
RESPONSIBLE AGENCY: National Space Development Center
TEST VEHICLE PERFORMANCE: Rocket fired at 80° angle carried 88 lbs. payload to 93.8-mi. altitude
TEST VEHICLE CONFIGURATION: Solid booster plus liquid sustainer; mean booster thrust, 13,200 lbs., sustainer, 2,205 lbs.; burning time booster, 10 sec., sustainer, 25 sec.; rocket weight, 1,672 lbs.
REMARKS: Main purpose of flight testing is to get experience on launching multi-stage rockets

S-B (sounding rocket)

TYPE: Meteorological
STATUS: Development
RESPONSIBLE AGENCY: National Space Development Center
TEST VEHICLE PERFORMANCE: Rocket fired at 70° angle carried 5-lb. instrument package to 37.5-mi. altitude
TEST VEHICLE CONFIGURATION: Single-stage solid rocket weighed 103 lbs., mean thrust 1,694 lbs., burning time 8 sec.
REMARKS: Two-channel telemetry; instrument-package parachute-recovered; rocket body made of plastic

LEBANON

Cedar 4 (rocket)

TYPE: Surface-to-air
STATUS: Development
CONFIGURATION: Single-stage, solid-fuel; four fins aft
REMARKS: Test launchings of vehicle and components conducted during 1964; low-quality photo gives vehicle appearance of being two-stage sounding rocket, but caption describes it as a weapon and says it can reach altitudes of 15 mi.; what it expects to combat at that altitude not explained

NORWAY

Terne III (missile)

TYPE: Anti-submarine
STATUS: Operational on Norwegian and U.S. ships
PRIME CONTRACTOR: Kongsberg Vapenfabrikk
PERFORMANCE: Short to medium range; firing sector 360 degrees
CONFIGURATION: Length, 6.5 ft.; diameter, 7.9 in.
GUIDANCE: None
FIRE CONTROL: Sonar, computers and remote-control launcher
PROPULSION: Solid
PAYLOAD: Terne H.E. Missile Mk 7
REMARKS: Can fire a 6-missile salvo in 5 sec.; salvo reload time is 40 sec.

SOUTH AFRICA

Surface-to-Air (missile)

TYPE: Anti-aircraft
STATUS: Early R&D
RESPONSIBLE AGENCY: Rocket Research Institute, Council for Scientific and Industrial Research, Pretoria
PRIME CONTRACTOR: Unannounced, if any
REMARKS: Bare announcement made Oct. 27, 1963, by government spokesman who said: "The Republic has been forced by events in Africa to enter the missile field," and added that a test range is to be set up somewhere in the republic

SWEDEN

08 (missile)

TYPE: Surface-to-surface naval weapon
STATUS: Development
PRIME CONTRACTOR: Saab Aircraft Co.
PROPULSION: Jet engine
CONFIGURATION: Span, 10 ft.; length, 18 ft.; wings foldable
REMARKS: Based on French target missile (CT 20), missile under joint development of France and Sweden

Adam (missile)

TYPE: Air-to-surface
STATUS: Operational
PRIME CONTRACTOR: AB Bofors
CONFIGURATION: Length, 5.9 ft.; weight, 92.4 lbs.; HE warhead
GUIDANCE: None

Bantam (missile)

TYPE: Anti-tank
STATUS: Operational
PRIME CONTRACTOR: AB Bofors
PERFORMANCE: Range, 300 to 2,200 yds.; speed, 190 mph; charge of 3.1 lbs. reportedly penetrates 20 in. of armor plate
CONFIGURATION: Length, 33 in.; diameter, 4.3 in.; span, 15.8 in.; launch weight, 13.2 lbs.; glass fiber frame; weight of container and missile, 24 lbs.
PROPULSION: Solid, in two sections
GUIDANCE: Wire
REMARKS: Lightweight, weapon uses double sheath fuze (dia. 110 mm) ensuring functioning at impact angle of 5°, or after impact against protective tank devices

TERNE III

08

Erika (missile)

TYPE: Anti-submarine

STATUS: Operational

PRIME CONTRACTOR: AB Bofors

PERFOMANCE: Range up to 2,000 yds.; sinking speed six fathoms per sec.

CONFIGURATION: Length with proximity fuze, 6.5 ft.; weight with fuze and hexotonal 375 mm charge, 550 lbs.

REMARKS: Can use inner solid-fuel motor and outer motor singly or together

Flora (missile)

TYPE: Anti-submarine

STATUS: Operational

PRIME CONTRACTOR: AB Bofors

PERFORMANCE: Maximum range, 2,600 yds.

CONFIGURATION: Length with proximity fuze, 6.5 ft.; weight with fuze and hexotonal 375 mm charge, 532 lbs.

Frida, Gerda (missiles)

TYPE: Air-to-air

STATUS: Operational

PRIME CONTRACTOR: AB Bofors

CONFIGURATION: Length, 4.3 ft.; weight, 15.4 lbs.

PERFORMANCE: Max. range, 2,200 yds.; penetrates more than 20-in. armor plate

GUIDANCE: None

REMARKS: Gerda is the advanced system; HE warheads

M-20 (missile)

TYPE: Surface-to-surface, anti-ship

STATUS: Development

RESPONSIBLE AGENCY: Swedish Navy

CONTRACTOR: Nord Aviation and CSF, of France, under development contract to Swedish Navy; Saab has license for Swedish manufacture

PERFORMANCE: Details scarce; however, details of the drone version CT-20 are: speed, Mach 0.85 at 33,000 ft.; endurance at 31,000 ft., 1 hour; ceiling, 39,000 ft.

CONFIGURATION: Length, 17.7 ft.; fuselage diameter, 2.17 ft.; wingspan, 11.6 ft.; wing area, 34.1 sq. ft.; launch wt., 1,480 lbs.; engine thrust, 880 lbs.; ramp-launched

GUIDANCE: Radio-command, with at least nine signal modes; target version is visualized for remote operator by luminous spot on a course platter; this may be altered in the missile version

PROPULSION: Marbore turbojet, boosted by two jettisonable solid rockets

REMARKS: Sweden selected the French CT-20 target drone for conversion to a weapon to replace the Robot 315/316 anti-ship missile; development began in spring, 1959, with operational missile reportedly 50% heavier than target version, so performance and configuration details shown above will be altered to an unknown extent; final development began December, 1961, but operational date unknown; automatic handling system of Robot 315/316 adaptable to handle M-20; budget allocation for one coastal-defense battery complete was $17 million; cost of ship installation unknown

Robot 304 (missile)

TYPE: Air-to-surface

STATUS: Operational

PRIME CONTRACTOR: Swedish Guided Missile Bureau and Royal Swedish Armed Forces Research Establishment

PERFORMANCE: Range, over 3 mi.

CONFIGURATION: Length, 14.8 ft.; span, 6.8 ft.; dia., 19.4 in.; launch weight, 1,200 lbs; four canard fins, small wings

GUIDANCE: Radio command and autopilot

PROPULSION: Solid

Robot 315 (missile)

TYPE: Ship-to-shore

STATUS: Operational, phasing out

PRIME CONTRACTOR: Swedish Guided Missile Bureau and Royal Swedish Armed Forces Research Establishment

PERFORMANCE: Range, 10 mi.

CONFIGURATION: Length, 24 ft.; launch weight, 3,000 lbs.: four fins at midpoint, four small fins forward

PROPULSION: Solid booster and solid sustainer

GUIDANCE: Radio command

REMARKS: Being replaced by M-20

RRX-1 (rocket)

TYPE: Ramjet experimental vehicle

STATUS: R&D

PRIME CONTRACTOR: Svenska Flygmotor Aktiebolaget

PERFORMANCE: Mach 2 to 6

CONFIGURATION: Length, 6.9 ft.; diameter, 7.5 in.

Saab 305A (missile)

TYPE: Air-to-surface

STATUS: Development

PRIME CONTRACTOR: Svenska Aeroplan Aktiebolaget

CONFIGURATION: Two-stage solid with one combustion chamber and one blast tube, body 1-ft.-dia., 11 ft. 7 in. long, 2 ft. 8 in. wingspan, 660 lbs. gross weight

WARHEAD: Proximity fuse and charge systems

CHARACTERISTICS: Supersonic, 4 highly swept fins, control surfaces in rear

REMARKS: New missile system defined by Swedish air force as important weapon alternate for the AJ37 and A60 aircraft

SWITZERLAND

Mosquito 64 (missile)

TYPE: Anti-tank, anti-personnel

STATUS: Operational

PRIME CONTRACTOR: Contraves AG, Zurich

PERFORMANCE: Range 400 yds. to 2,600 yds.; two alternate warheads: hollow charge head (9 lbs.) penetrating more than 26 in. armor plate; fragmentation warhead with splinter density of more than six per sq. yd. at 20 yds. distance

CONFIGURATION: Length in container, 25 in.; shell diameter, 4.7 in.; weight of container and missile, 53 lbs.

GUIDANCE: Wire

REMARKS: Several hundred units produced each month in joint manufacturing by Swiss Contraves and Italian Contraves plants

Sura 8-80 (missile)

TYPE: Air-to-surface

STATUS: Operational

PRIME CONTRACTOR: Hispano-Suiza (Suisse), S. A.

PERFORMANCE: Thrust, 2,640 lbs.; in volley tests from aircraft at 497 mph, 50% dispersion was 10 milliradians

U S S R: SPACE SYSTEMS

Cosmos

TYPE: Space research satellites

MISSION: Check and improve "elements of space vehicle construction" and carry out research into problems posed by the space environment

STATUS: Operational, frequent launches carried out

PERFORMANCE: Orbits ranging from 107 to 900 mi. altitude; angles of inclination are 49 and 65 degrees

CONFIGURATION: Unavailable for entire series; believed to be larger than Vostok series

SPACE BOOSTER: Smaller, higher powered military rocket which was tested by firing into the Pacific Ocean during fall of 1961

PAYLOAD: Particle counters; magnetometers, micrometeorite impact sensors, and possibly cameras for surveillance

REMARKS: One of most secretive Soviet space programs; has had many launches of alleged scientific nature, but scientific results have never been released; Cosmos program began in March, 1962, and has launched an average of one satellite monthly; judging from remarks by Soviet leaders, at least some Cosmos satellites may be reconnaissance vehicles similar to U.S. SAMOS; seventy-five Cosmos satellites launched as of July 16

Elektron (satellite)

TYPE: Radiation belt research

STATUS: Multiple-launch satellites. First pair orbited Jan. 30, 1964, second pair July 11, 1964

PERFORMANCE: Reportedly excellent; Ek I orbit completely within limits of inner Van Allen belt with apogee of 3,800 mi.; Ek II intended to traverse both belts with apogee of 36,750 mi. Ek III apogee 4,365 mi. Ek IV, 41,076 mi.

CONFIGURATION: Ek I is approximately cylindrical, with numerous solar paddles and antennas and a hermetically sealed body; no dimensions or weights released; Ek II is apparently much larger, having fixed solar cells on its cylindrical sides, wide flared skirt and a long probe extending from its tapered nose; no dimensions or weights released; Ek III & IV presumably same configuration

INSTRUMENTATION: Ek I: 5 scintillation, gas discharge and semiconductor radiation counters; soft corpuscular radiation detectors; beacon; piezoelectric micrometeorite detectors; mass spectrometer; solar cell samples for tests; Ek II: same radiation instrumentation as Ek I; solar cell samples; electrostatic spherical analyzer; mass spectrometer; two ferrosonde magnetometers; solar X-radiation and Cherenkov counters; scintillation counters; radio noise detectors; charged particle trap

POWER: Level unknown, supplied by solar cells and, presumably, batteries

CONTROL: Ground command, with claim that changes in orbital parameters may be accomplished; control reliability claimed to be high

TELEMETRY: On-board storage and readout by command as well as continuous transmission

REMARKS: Soviets have released considerable detail on the equipment contained with I & II payloads, but not on equipment design nor the dimensions of the overall package; III & IV radiation monitors inner and outer belts, magnetosphere

Luna

TYPE: Space and lunar research vehicles

STATUS: Four flights—Jan. 2, Sept. 12, Oct. 4, 1959, and April 2, 1963. Luna I—solar orbit; Luna II—impacted Moon; Luna III—photographed far side of Moon and presumably burned up in Earth's atmosphere in April, 1960; Luna IV launched April 2, 1963 missed Moon by 4,600 n. mi.; Luna V crash-landed on Moon May 11; Luna VI launched June 8 went into heliocentric orbit

FRAME: Luna I & II—dimensions not released; total weight, 3,245 lbs., instruments, 800 lbs. for I and 858 lbs. for II; Luna III—cylindrical, length 87 in., diameter 47 in.; weight, 4,037 lbs. total, 959 lbs. instruments; Luna IV & VI dimensions unavailable; weight, 3,135 total; Luna V, 3,250 lbs.

INSTRUMENTATION: Internal temperature and pressure measurement instruments; devices to study gas components of interplanetary matter and corpuscular radiation of Sun, magnetic fields of Earth and Moon, meteoric particles and heavy nuclei in primary cosmic radiation; Luna III also had two cameras, developing equipment, and automatic triggering devices for cameras, resulting in transmission of photos of far side of Moon

SPACE BOOSTER: Believed to be modified T-3 three-stage ICBM

REMARKS: Formerly called Lunik; Luna II impacted on the Moon with instruments and a Soviet coat-of-arms; was also called Mechta (Dream). Luna III transmitted photographs showing 70% of Moon's far side

Mars I

TYPE: Unmanned interplanetary probe, launched Nov. 1, 1962

PERFORMANCE: Speed after Earth escape, 8,793 mph. Data on Earth's radiation belts as well as space measurements at distances up to 66 million miles from Earth were successfully transmitted

CONFIGURATION: Two hermetically sealed compartments, orbital and planetary. Maximum length 10 ft. 10 in., 3 ft. 7 in. diameter in the orbital compartment, maximum width 13 ft. 1½ in. including solar batteries and radiators. Weight 1,980 lbs.

INSTRUMENTATION: Photo television assembly for photographing Martian surface. Spectro-flexometers, spectrograph, magnetometers, radio telescope, sensors to measure low-energy protons and electrons

POWER: Chemical and solar batteries

REMARKS: Mars probe launched on interplanetary trajectory from Earth orbit. Soviets predicted vehicle would come within 120,000 miles of Mars without a midcourse guidance correction. Radio contact with spacecraft lost March 21, 1963

Molniya I

TYPE: Communications satellite

MISSION: Provides transmission over Soviet Union for periods up to 9 hours in both black and white, and color; active relay

ORBIT: Apogee 21,250 n. mi.; perigee 268 n. mi.; inclined 65° to equator, period 11 hrs., 48 min.; apogee in Northern Hemisphere

REMARKS: Launched April 23, 1965

Proton I

TYPE: Unmanned scientific satellite

MISSION: Carries instruments for measuring cosmic particles of extremely high energy

REMARKS: Heaviest payload (26,000 lbs.) yet orbited; employed new booster, announced purpose of which is "to insure the realization of the planned space research program"

Venus Probes

TYPE: Interplanetary probe launched from Earth satellite

STATUS: At lease four attempts known; no successes

PERFORMANCE: Poor; difficulty in transferring from parking orbit to interplanetary trajectory; first probe missed Venus by over 600,000 miles; remainder have been stymied while still in Earth orbit

CONFIGURATION: Probe—cylindrical payload; length, 80 in; diameter, 41 in without solar paddles and antennas; weight, 1,419 lbs; configuration of Earth satellite vehicle unknown

INSTRUMENTATION: Cosmic radiation, magnetic field, micrometeorite, and other detectors; stabilization, temperature control, telemetry and other control equipment

REMARKS: May 22, 1963, attempt apparently disintegrated while still in Earth orbit, NASA lists rocket stages and 24 pieces in orbit but no transmission information; considerable difficulty experienced by USSR in transferring all interplanetary vehicles from Earth orbit. Sputnik VII, Sputnik VIII and the unnamed May 22 satellite are considered abortive attempts

Voskhod

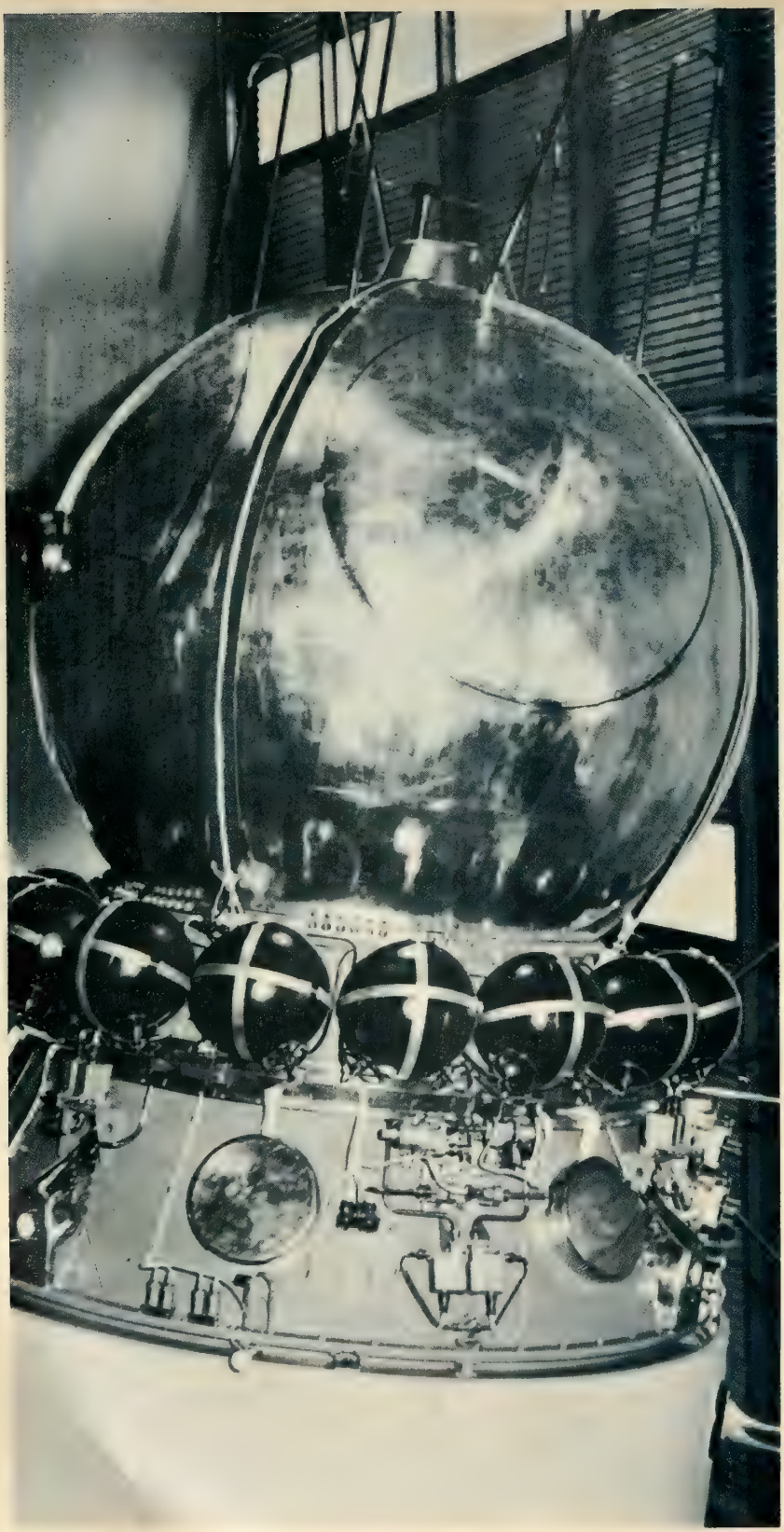
TYPE: Manned spacecraft

PERFORMANCE: Voskhod I, 16-orbit flight, 24 hours, 17 minutes; Voskhod II, 17-18-orbit flight, about 26 hours

CREW: Voskhod I, first three-man crew (V. Komarov, K. Feoktistov and B. Yegorov); launched from Tyuratam Oct. 12, 1964; Voskhod II with two-man crew (A. Leonov and P. Belyayev), first "space walk;" on second orbit co-pilot Leonov, using self-contained life-support system, left spacecraft through airlock for 10 minutes and returned; launched from Tyuratam March 18, 1965

ORBIT: Voskhod I, period 90.1 min., perigee 100 mi., apogee 255 mi., inclination to equator 65°; Voskhod II, period 90.0 min., perigee 107 mi., apogee 308 mi., inclination to equator 65°

CONFIGURATION: Voskhod I weight 11,070 lbs.



VOSTOK

Vostok

TYPE: Manned spacecraft

STATUS: Single flights, Vostok I, April 12, 1961, and Vostok II, Aug. 6, 1961; two double flights, Vostok III & IV, Aug. 11/12, 1962; and Vostok V and VI, June 14/16, 1963

PERFORMANCE: Vostok I, one orbit at 187/108 mi.; Vostok II, 17½ orbits at 115/110 mi.; Vostok III, 64 orbits at 145/112 mi.; Vostok IV, 48 orbits at 147/111 mi.; Vostok V, 82 orbits at initial 130/108 mi.; Vostok VI, 49 orbits at 133.9/109 mi.

FRAME: Overall length (est.) 35 ft.; diameter (est.) 8.8 ft.; re-entry body (est.) 17 ft.; total weight, Vostok 1, 10,418 lbs.; Vostok II, 10,430 lbs.; Vostok III, "about 5 tons;" Vostok IV, same; Vostok V, same; Vostok VI, same

INSTRUMENTATION: Radio & TV equipment for biomedical monitoring, automatic life support equipment; both automatic and manual control equipment; biomedical specimens for radiation experiments

SPACE BOOSTER: Not revealed

REMARKS: Two near-rendezvous double flights have been carried out by the USSR, and the second seemed to go awry. Vostok VI carried a woman; Vostok V appeared to be in improper orbit, which decayed rather rapidly and was considerably different from that of its running mate, preventing any possibility of rendezvous

Zond

TYPE: Interplanetary probes

MISSION: Zond I, launched April 2, 1964, developed for interplanetary flights, apparently failed in its mission; Zond II launched Nov. 30, 1964, as a Mars probe went out of contact May 6, 1965; flyby of red planet expected Aug. 6, 1965; Zond II included first use of ion engines for stabilization; Zond III, launched July 18, appeared to be headed for Sun; announced purposes of Zond III are to test automatic systems in "prolonged" space flights and holding scientific studies of interplanetary space

PERFORMANCE: In heliocentric orbits

U S S R: MISSILES

Air-to-Air

TYPE: Interceptor armament
STATUS: Unknown
PERFORMANCE: Unknown
CONFIGURATION: Length about 9.5 ft.; body dia. about 6.5 in.; main fin span about 39 in.; rear fin span about 35 in.; has one set of four sharply swept delta fins and one set of narrow swallow cruciform fins at tail
PROPULSION: Presumably solid
GUIDANCE: Unknown
REMARKS: Armament of Soviet "Fiddler" interceptor

Air-to-Air

TYPE: Long-range interception
STATUS: Unknown
PERFORMANCE: Unknown
CONFIGURATION: Length 14.2 ft.; dia. 9 in.; rear fin span 45 in.; forward fin span 34 in.; two sets of swallow fins, one set at tail and other about midpoint
PROPULSION: Presumably solid
GUIDANCE: Unknown
REMARKS: This weapon has been publicly shown mounted on a Soviet interceptor known to NATO as "Flipper" Mig-23

Air-to-Air

TYPE: Interceptor armament
STATUS: Operational
PERFORMANCE: Unknown
CONFIGURATION: Length, 9.75 ft.; body dia. about 4 in.; rear fin span about 19 in.; forward fin span about 10 in.; appears to be in Sidewinder class, but longer and thinner
PROPULSION: Presumably solid
GUIDANCE: Unknown, but believed IR

Air-to-Surface

TYPE: Bomber standoff weapon
STATUS: Presumably operational
PERFORMANCE: Unknown
CONFIGURATION: Length about 19 ft. overall; height (incl. fin) about 6 ft.; body dia. about 4 ft.; appears similar to Ryan Firebee; has two aerodynamic "fences" on upper surface of each wing
PROPULSION: Apparently turbojet
GUIDANCE: Unknown
REMARKS: Wing-mounted under Badger bombers at public displays; may not be a missile at all, but a target drone

Air-to-Surface

TYPE: Bomber standoff weapon
STATUS: Presumably operational
PERFORMANCE: Unknown
CONFIGURATION: Length about 32 ft.; body dia. about 3.75 ft.; overall ht. (incl. vertical fin and engine nacelle) about 8.5 ft.; horizontal wing and fin spans unknown; appears to be in Hound Dog class, with shorter and fatter body, as well as rear horizontal stabilizers instead of canard arrangement
PROPULSION: Turbojet or ramjet
GUIDANCE: Unknown
REMARKS: Carried in public displays by Soviet "Badger" bombers under fuselage

Air-to-Surface

TYPE: Bomber standoff weapon
STATUS: Unknown, presumably operational
PERFORMANCE: Unknown
CONFIGURATION: Length about 58 ft.; dia. about 7 ft.; wingspan, unknown; height (incl. fin) about 13 ft.; winged, pilotless-bomber type design
PROPULSION: Unknown, probably turbojet
GUIDANCE: Unknown
REMARKS: Carried in public displays by Soviet "Bear" bombers

Air-to-Surface

TYPE: Tactical strike
STATUS: Presumably operational
PERFORMANCE: Unknown, probably in Bullpup class
CONFIGURATION: Length 11.5 ft.; body dia. about 1 ft.; rear fin span 3 ft.; forward fin span about 1.75 ft.; resembles Bullpup AGM-12
PROPULSION: Presumably solid
GUIDANCE: Unknown
REMARKS: Carried in public displays by Soviet fighter-bombers

Air-to-Surface

TYPE: Bomber standoff weapon
STATUS: Presumably operational
PERFORMANCE: Unknown
CONFIGURATION: Length about 30 ft.; max. body dia. 3.5 ft. at air intake duct; vertical fin span about 7 ft.; appears to be in Blue Steel class
PROPULSION: Apparently turbojet or ramjet
GUIDANCE: Unknown
REMARKS: Carried in public displays by "Blinder" supersonic bomber

Air-to-Surface

TYPE: Helicopter armament
STATUS: Presumably operational
PERFORMANCE: Unknown
CONFIGURATION: Length about 8 ft.; dia. about 1 ft.; rear fin span about 3 ft.; forward fin span about 2 ft.; two sets of cruciform fins, with rear set apparently fixed and forward set movable
PROPULSION: Presumably solid
GUIDANCE: Unknown
REMARKS: Carried by Soviet helicopter "Harp" in public display

Anti-Missile-Missile

TYPE: Re-entry body interception
STATUS: Unknown; probably early development
PERFORMANCE: Unknown; Soviet claim is that it can hit "a fly in outer space"
CONFIGURATION: Length about 47 ft.; dia. of booster 34.2 in.; dia. of sustainer 25 in. (all dimensions approximate); three sets of fins, one cruciform set fixed at base of booster, one small all-moving set at base of sustainer, and one large cruciform set at three-quarter point on sustainer including ailerons and stub antennas for guidance commands
PROPULSION: Probably solid
GUIDANCE: Probably radar command
REMARKS: Shown to public in Red Square on Nov. 7, 1963; some resemblance has been noted between portions of this weapon and the earlier surface-to-air weapons called SA-2 and SA-3

Big Brother

TYPE: ICBM
STATUS: Operational
PERFORMANCE: First stage thrust believed to exceed 1 million lbs.
PROPULSION: Solid fuel
REMARKS: Soviets claim use as a launch vehicle for VOSTOK and VOSKHOD

Frog II

TYPE: Tactical surface-to-surface
STATUS: Operational
PERFORMANCE: 17 mi.
CONFIGURATION: Length 30 ft.; diameter 2 ft.; weight 2.4 tons
PROPULSION: Solid
GUIDANCE: Unguided
REMARKS: During the flight, it is spin-stabilized; launched on PT-76 amphibious reconnaissance tank

Frog III

TYPE: Tactical surface-to-surface
STATUS: Presumably operational
PERFORMANCE: 22-28 mi.
CONFIGURATION: Length 35 ft.; diameter 2 ft.; weight 2.2 tons
PROPULSION: Solid
GUIDANCE: Unguided
REMARKS: Like Frog II, has 4 stabilizing fins near the tail; also launched by PT-76 tank

Frog IV

TYPE: Tactical surface-to-surface
STATUS: Presumably operational
PERFORMANCE: 31 mi.
CONFIGURATION: Length 35 ft.; diameter 1.5 ft.; weight 2.1 tons
PROPULSION: Solid
GUIDANCE: Unguided
REMARKS: Probably greater CEP; smaller stabilization fins than predecessors in this group; also launched from armored launcher

Gannef

TYPE: Surface-to-air
STATUS: Apparently operational
PERFORMANCE: Uncertain, but appears capable of Mach 2.5 operation at 15- to 18-mi. altitudes and slant range of 50 to 62 mi.
CONFIGURATION: Length about 28 ft.; afterbody dia. about 3 ft.; diffuser dia. about 15-18 in.; weight 1.8 to 2.2 tons; two large sets of cruciform fins, forward set all-moving, after set fixed; four solid-propellant strap-on motors to accelerate vehicle to ramjet ignition velocity; ramjet body apparently integral with overall structure and no warhead separation occurs; center diffuser body projects about 8 ft. forward of ramjet intake lips and tapers to long point
GUIDANCE: Unknown
REMARKS: Actual mission of missile in doubt, since it could conceivably be either anti-aircraft or for close support of troops, although it is large enough to be an antiaircraft weapon; is launched from a tracked vehicle equipped with an elevation beam; each vehicle carries two missiles with TNT warheads

NOVOSTI PRESS AGENCY

GOA

TYPE: Surface-to-air

STATUS: Presumably operational

PERFORMANCE: Altitude 5 to 8 mi.; slant range 10 to 12 mi.; speed Mach 2-2.5

CONFIGURATION: Length 20 ft.; diameter 1 ft.; weight 0.4 to 0.6 ton

WARHEAD: TNT

PROPULSION: Solid

REMARKS: Booster has four crosswise, rectangular stabilizers; tail has four delta-shaped stabilizers & warhead has four rectangular stabilizers; double-launcher truck carries two missiles

Guild

TYPE: Surface-to-air

STATUS: Presumably operational

PERFORMANCE: Approximately 12-mi. altitude; 18 to 20-mi. slant range; speed, Mach 2.5

CONFIGURATION: Length 38 ft.; diameter 2 ft.; weight 3 tons

WARHEAD: TNT

PROPULSION: Liquid

REMARKS: Deployed by Soviet air defense from fixed positions; has four rhomboid-shaped stabilizers arranged crosswise with 4 smaller stabilizers on the warhead

NOVOSTI PRESS AGENCY

Griffon

TYPE: Surface-to-air

STATUS: Presumably operational

PERFORMANCE: Altitude 25 to 30 mi.; slant range 95 to 110 mi.; speed Mach 3-5

CONFIGURATION: Length 52 ft.; diameter 3 ft.; weight 2.5 tons

WARHEAD: TNT and possibly nuclear

PROPULSION: First stage solid; second stage liquid

REMARKS: Has four triangular stabilizers at the tail of the first stage, four smaller fins at tail of second stage with four larger fins farther in front; may also be used as an anti-missile missile, according to Soviet statements

Sandal

TYPE: Surface-to-surface MMRBM

STATUS: Obsolescent

PERFORMANCE: Range believed to be on order of 350-400 mi.

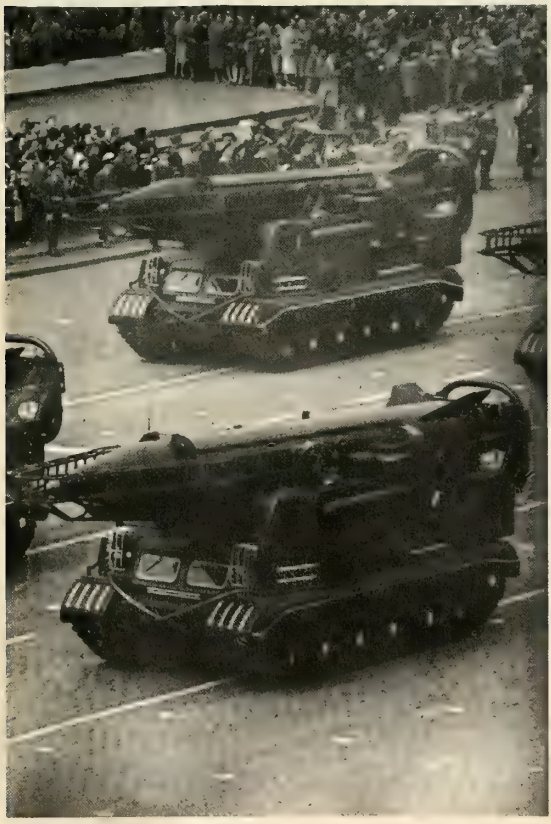
CONFIGURATION: Length 66.5 ft.; dia. 5.6 ft.; four small fins at tail similar to fins first seen on Thor IRBM and later removed; constant diameter throughout length of frame

PROPULSION: Liquid rocket, believed using LOX/RP-1; thrust unknown, but probably in 70-80,000 lb. class

GUIDANCE: Unknown

REMARKS: One of earliest shown Soviet long-range missiles; believed to be the aging offspring of the V-2 continuation carried out in the USSR by German workers after the war; now replaced by Shyster

NOVOSTI PRESS AGENCY



Guideline (SA-2)

TYPE: Surface-to-air

STATUS: Probably still operational

PERFORMANCE: Altitude 12 mi.; slant range 18 mi.; speed Mach 2.5

CONFIGURATION: Length 35 ft.; diameter 2 ft.; weight 2.5 tons

WARHEAD: TNT

PROPULSION: First stage solid; second stage liquid

REMARKS: Improved version has altitude of 15 mi., slant range of 25 mi. and travels at Mach 3; the oldest, combat-ready type still used by Warsaw Pact nations; has a nose rod and four small stabilizers in earlier version; improved version has no nose rod & has enlarged delta-shaped stabilizers at warhead; deployed by USSR in Cuba, United Arab Republic, other countries; presumably the weapon used to down several U-2 aircraft

Scud A

TYPE: Tactical surface-to-surface

STATUS: Presumably operational

PERFORMANCE: 102 mi.

CONFIGURATION: Length 32 ft.; diameter 3 ft.; weight 4.4 tons

PROPULSION: Liquid

GUIDANCE: Radio command

REMARKS: Has four stabilizers; launched on JS-3 tank chassis with ladder-like transport and elevation gear

BIG BROTHER

GUIDELINE

SCUD B

Scud B

TYPE: Tactical surface-to-surface
STATUS: Unknown
PERFORMANCE: 136 mi.
CONFIGURATION: Length 37 ft.; diameter 3 ft.; weight 5 tons
PROPULSION: Storable liquid
GUIDANCE: Inertial

Shaddock

TYPE: Tactical surface-to-surface
STATUS: Unknown
PERFORMANCE: 186 to 248 mi.
CONFIGURATION: Length 36 ft.; diameter unknown; weight 5 to 7 tons
PROPULSION: Unknown
GUIDANCE: Inertial
REMARKS: Known to exist but not yet seen in public; launched from a container closed at each end during transport

Shyster

TYPE: Strategic surface-to-surface missile
STATUS: Presumably operational
PERFORMANCE: 750 to 950 mi.
CONFIGURATION: Length 75 ft.; diameter over 6 ft.; four very small fins at tail; constant diameter throughout length of frame
PROPULSION: Liquid
GUIDANCE: Inertial
REMARKS: Mobile use possible; transported by 2-axle trailer; towed by tractor of AT-T type; the smallest strategic missile; improved version, first shown in November, 1964, is slightly larger, weighs from 28 to 30 tons and has a range of 1,550 to 1,860 mi.; may use storabel fuel; updated version of Sandal; is relatively mobile and approximate counterpart of Redstone with improved performance

Snark*

TYPE: Submarine-launched, ballistic
STATUS: Unknown, but believed to be deployed in limited quantities
PERFORMANCE: Unknown; open to speculation as to whether underwater launch is possible
CONFIGURATION: Length about 47.5 ft.; max. dia. 5.9 ft.; 4.1 ft. at smallest cylindrical section; no fins or other major protrusions, but cluster of what are apparently seven rocket nozzles at base; may have as many as three stages
PROPULSION: Very likely solid propellants
GUIDANCE: Unknown, probably all-inertial
REMARKS: Described as both a shipboard and field weapon
**NATO code name*

Snapper

TYPE: Anti-tank
STATUS: Unknown
PERFORMANCE: 310 to 1,240 mi.
CONFIGURATION: Length 3.3 ft.; diameter 6 in.; (estimated)
PROPULSION: Unknown
GUIDANCE: Wire-guided
REMARKS: Launched on rails mounted on the rear of an amphibious scout car or truck; has relatively large stabilizing fins arranged cross-wise and slanted in front; warhead is conically shaped

SS2

TYPE: Tactical surface-to-surface
STATUS: Assume still operational, but production stopped
PERFORMANCE: 280 to 310 mi.
CONFIGURATION: Length 52 ft.; diameter 6 ft.; weight 16 tons
PROPULSION: Liquid
GUIDANCE: Radio command
REMARKS: Soviet version of German V-2; although production has been discontinued, it must be considered probably still deployed because of the large numbers produced

SS5

TYPE: IRBM
STATUS: Probably obsolete
PERFORMANCE: 1,860 mi.
CONFIGURATION: Length 85-90 ft.; diameter 8-10 ft.; weight 40-50 tons
PROPULSION: Liquid
GUIDANCE: Radio command
REMARKS: Launched from hard bases in Western Soviet Union; believed to be deployed in from 40 to 60 bases

SS6

TYPE: ICBM
STATUS: Operational
PERFORMANCE: 5,000-6,200 mi.
CONFIGURATION: Length about 100-110 ft.; diameter about 12 ft.; weight 90-100 tons
PROPULSION: Liquid, 2 or 3 stages
GUIDANCE: Radio command
REMARKS: First-generation ICBM; launched from hard sites; thermonuclear warhead; possibly some deployed in hardened sites; launch control centers responsible for more than one missile; vehicle believed used for Soviet space launches

SS7

TYPE: ICBM
STATUS: Operational
PERFORMANCE: 6,200-7,500 mi.
CONFIGURATION: Length 80 ft.; diameter 10 ft.; weight 60-80 tons
PROPULSION: Storable liquid
GUIDANCE: Inertial
REMARKS: Isolated hardened launch bases seen by U-2 aircraft; estimated there are 180-200 such bases

Little Sister

TYPE: Surface-to-air
STATUS: Unknown
PROPULSION: Presumably solid
CONFIGURATION: About 55 ft. long; diameter, 6 ft.
REMARKS: Probably a Minuteman-class ICBM, shown for the first time publicly, May 9, 1965, at the Kremlin in Moscow

SA-3

TYPE: Surface-to-air
STATUS: Unknown
PERFORMANCE: Unknown, but obviously improved over SA-2, which is believed to have hit several U-2 aircraft
CONFIGURATION: Length about 37.5 ft. overall; body dia. about 20 in.; four large fins about three-quarters of the length back have movable tabs, and four smaller fins near nose appear movable; staging point is not as obvious as in SA-2, and version seen may have been without boost motor
PROPULSION: Presumably solid
GUIDANCE: Presumably radar-command
REMARKS: Details speculative

A Chronology of Fiscal 1965

JULY 1964

June 30 week: Maj. Gen Alvin R. Leudecke sent to Jet Propulsion Laboratory to take over NASA's unmanned lunar and planetary spacecraft programs.

—Senate and House Space Committee conferees approve $5.227-billion NASA authorization bill; passage by both Houses follows.

—First American Institute of Aeronautics and Astronautics meeting held in Washington, D.C.

—Dr. Harold W. Ritchey selected president of Thiokol Chemical Corp., succeding J. W. Crosby, who became chairman of the board.

July 1: Soviet Union orbited *Cosmos 34*, the 10th such scientific satellite launch of the year.

July 2: *Polaris A-3* test program comes to an end with launch from land-pad at Cape Kennedy; 2,500-mile launch was 41st of advanced *Polaris*.

July 7 week: DOD formally announces it is cancelling *Low-Altitude Supersonic Vehicle (LASV)* with Pluto nuclear ramjet engine.

July 8: NASA test pilot Joe Engle flies *X-15* to 170,000 ft., 3,511 mph.

—Air Force achieves first success in three launches of *Athena* re-entry test series. Missile travelled 470 mi. from Green River, Utah, launch site to predetermined impact area at White Sands Missile Range carrying subscale reentry payload.

July 13 week: DOD decides to proceed with development of military *Medium-Altitude Communications Satellite (MACS)* system, suspending talks with Communications Satellite Corp.

—NASA reveals it is considering dropping 1966 Mar fly-by mission.

—Republican Party, in election year statement, pledges to stretch out space program funds and divert them to other areas, and revitalize military developments.

July 15: Soviet Union launches 35th *Cosmos*.

July 16: NASA launches *Nike-Apache* carrying 84 lbs. of instruments 85 mi. above Cape Kennedy to test effects of ionosphere on radio frequencies.

July 17: Air Force launches second pair of *Nuclear Detection Satellites* (formerly *Vela Hotel* and *Vela High Altitude*) on *Atlas-Agena*, with 4.5-lb. pigmy satellite to study electrons in the Van Allen radiation belt.

July 20: *SERT I* spacecraft fired in ballistic shot from Wallops Island.

July 20 week: Rep. Porter Hardy (D-Va.) chairs House Armed Services Special Investigating Subcommittee in probe of health and welfare expenses of government contractors.

July 22: Air Force launches and recovers *ASSET* materials testing vehicle from Cape Kennedy, first total success in three firings of the craft.

July 22: Japan launches first weather observation rocket from Nii Island testing ground.

July 27 week: President Johnson discloses development of SR-71 Mach 3 reconnaissance plane.

—Senate Appropriations Committee okays $46.8 billion for defense; Senate approves.

—Member nations of Communications Satellite Corp. comsat pact approve plans for organizational principles for international system.

July 28: *Ranger VII* launched from Cape Kennedy toward Moon.

July 30: *Hawk* air-defense missile intercepts Army *Roadrunner* in development tests at White Sands, N.M.

—Soviet Union launches 36th *Cosmos* successfully.

Aug. 1: French launch *Dragon* rocket to 275 ft. from Iceland base.

Aug. 3 week: Air Force announces plans to install an additional 50 *Minuteman* missiles at Malmstrom AFB, Mont.

—Senate approves $5.3 billion for NASA appropriations, bill goes to conference with House Appropriations Committee members.

—*Ranger VII* a success, returns photos of lunar surface with resolution 2,000 times greater than that of Earth-based telescopes.

—Douglas Aircraft Co. reported to be working on uprated *Delta* launch vehicle with capability of placing heavy payloads in polar orbit from Cape Kennedy.

Aug. 10 week: NASA receives final $5.25 billion from Congress in appropriations bill.

—Aerojet-General Corp. verifies filament-wound, glass-reinforced rocket motor case design and fabrication techniques with successful test of sub-scale chamber for 260-inch solid rocket motor.

Aug. 13: Great Britain successfully launches its first stabilized *Skylark* rocket from the Woomera, Australia, range.

Aug. 17 week: Soviets developing aerospace plane, Chief Air Marshal Konstantin Vershinin says in interview with Tass.

—Martin-Denver completes first successful sequenced compatibility firing of first two liquid stages of *Titan III*.

Aug. 18: Soviet Union launches *Cosmos* satellites *38*, *39* and *40* on single vehicle, said to be of new type.

Aug. 19: NASA uses *Thrust-Augmented Delta* to launch *Syncom III* from Cape Kennedy.

Aug. 22: Soviet Union launches three satellites on two vehicles, *Cosmos 41*, *42*, and *43*.

Aug. 24 week: NASA announces Electronics Research Center will be located in Cambridge, Mass., near Kendall Square.

—Letters readied for Secretary of Defense McNamara's signature to *MMRBM* contractors announcing that contracts will not be renewed.

—Air Force, Martin Co. recommend development of *Titan III-X*, non-manrated version of *Titan III-A*.

Aug. 25: NASA uses four-stage *Scout* rocket to put 97-lb. *Explorer XX* topside sounder satellite into near-polar orbit for ionospheric studies.

Aug. 28: *Nimbus I* weather satellite boosted by NASA on *Thor-Agena B* rocket from Vandenberg AFB. Intended 575-mi. circular orbit not attained, but satellite provided photographs from elliptical orbit.

Aug. 31. week: 260-in. solid rocket motor program assigned to NASA's Lewis Research Center in preparation for final turnover of program from the Air Force to NASA beginning in FY 1965.

—Army given go-ahead to pursue exploratory development for *Medium Antitank/Assault Weapon (MAW)*.

—Two Air Force Aerospace School pilots finish two-week simulation of manned orbital mission in simulation chamber at GE's Valley Forge Center.

SEPTEMBER 1964

Sept. 1: Air Force's hurricane-threatened *Titan III-A* launched four days late; first two stages work perfectly, but premature shutdown of Transtage engine causes failure to achieve orbit.

Sept. 4: NASA launches *Orbiting Geophysical Laboratory*, with 20 scientific experiments, from Cape Kennedy on *Atlas-Agena*.

Sept. 7 week: International Astronautical Federation held in Warsaw, Poland.

—House Armed Services Special Investigating Subcommittee calls for

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changes in ASPR's regarding provisions for contractors' employee health and recreation expenses.

Sept. 14 week: Dr. J. P. Ruina named head of the Institute for Defense Analysis to replace Richard M. Bissell.

—M/R Special Report on Anti-submarine Warfare.

Sept. 18: Boilerplate *Apollo* spacecraft orbited by *Saturn SA-7* completes 59 orbits, splashes down in Indian Ocean.

Sept. 21 week: *Nimbus I* weather satellite stops operating after solar panels lock and cannot be rotated toward Sun.

—Two anti-satellite systems revealed by President Johnson. One is based on *Nike-Zeus* and other on *Thor-Agena.*

Sept. 24: *Minuteman II* passes its first test when sucessfully launched from Cape Kennedy silo.

—Army-Marine Corps *Redeye* man-transportable anti-aircraft missile tested at China Lake, Calif., hits two of four targets.

—Soviet Union launches *Cosmos 46* satellite.

Sept. 28: First four-stage launch of *Athena* test rocket from Green River, Utah, termed partial success by Air Force in spite of in-flight abort caused by apparent malfunction.

Sept. 28 week: $309-million cost-plus-incentive-fee contract awarded to Western Electric Co. for continued development and testing of *Nike-X* anti-missile missile system in one of largest single contracts awarded by the Army.

—New YF-12A aircraft (A-11) publicly shown for first time by Air Force and Lockheed Aircraft Corp.

—Lockheed Propulsion Co.'s 156-in. solid motor fired in successful static test, with 2-min. 35-sec. burn time.

—*NERVA* reactor reaches 85% power in Nuclear Reactor Development Station at Jackass Flats, Nev., in successful test.

—DOD clamps down on employees in conduct memo limiting such favors as free lunches, souvenirs and hospitality suite invitations from contractors.

OCTOBER 1964

Oct. 2: Experimental re-entry vehicle carrying 25 experiments launched aboard *Titan II* from Vandenberg AFB in Defender program.

Oct. 3: NASA's *IMP 2* monitoring platform launched from Cape Kennedy, but falls short of intended orbital path of 161,000 mi., reaching maximum of 59,000 mi.

Oct. 5 week: Joint NASA/AEC Nuclear Propulsion Office reveals that second-generation nuclear rocket engine, powered by Phoebus, will have thrust of 250,000 lbs.

Oct. 9: NASA launches *Beacon Explorer B* from Wallops Island.

Oct. 12: Soviet Union launches three men on same spacecraft, *Voskhod,* and returns them safely after 24-hour, 16-orbit flight. One of three was first space-going physician.

Oct. 12 week: First all-metal mockup of Lunar Excursion Module shown at Grumman Aircraft's Bethpage plant.

—Tests of the $15-million X-band antenna facility at Haystack Microwave Research Facility begun at Tyngsboro, Mass., by Air Force.

Oct. 14: Soviet Union launches *Cosmos 48.*

Oct. 19: Japanese and American scientists use *Javelin Argo D-4* to launch 125 lbs. of scientific payload to 521 mi. from Wallops Island, Va.

Oct. 19 week: In left-handed manner, during political debate, Assistant Secretary of Defense for Public Affairs Arthur Sylvester reveals that DOD has approved *SRAM* air-to-surface missile, *Extended Range Asroc,* and *Arm 1.*

—Candidates Lyndon B. Johnson and Sen. Barry Goldwater outline views of U.S. space program future in M/R.

—NASA begins recruiting for 10-20 scientist-astronauts for future manned spaceflights.

Oct. 20: Britain successfully launches its second *Blue Streak* booster from Woomera, Australia.

Oct. 24: Soviet Union launches *Cosmos 49.*

Oct. 26 week: National Academy of Sciences disagrees strongly with NASA on post-*Appolo* plans, favoring vigorous, imaginative program of exploration of solar system.

Oct. 27: Soviet Union launches *Cosmos 50.*

Oct. 28: Air Force successfully launches fourth in its series of *ASSET* lifting-body experiments.

NOVEMBER 1964

Nov. 2 week: United Technology Center successfully tests thrust termination system of 120-in. solid motor developed for *Titan III-C.*

—Capt. Theodore C. Freeman, astronaut trainee, killed in jet trainer crash at Houston Nov. 1, buried in Arlington Cemetery Nov. 4.

—National election. President Lyndon B. Johnson re-elected. Some key Republicans in Space and Armed Services committees lose out in Democratic sweep.

Nov. 5: *Mariner III* launch fails when craft's shroud fails to clear probe.

Nov. 7: *Athena* is launched successfully,

the first time in four tries, from Green River, Utah.

Nov. 9 week: *Shillelagh* production contract won by Philco.

—NASA reveals it has all but cancelled real mission for *Voyager* in 1969; next assault on Mars to occur in 1971.

—*Apollo-X* plans outlined for consideration by Associate NASA Administrator Dr. Robert C. Seamans, Jr.

—Soviets display five new missiles in Red Square anniversary parade.

—General Dynamics shows plans for uprating *Atlas*.

Nov. 10-12: NASA conducts six-vehicle series of sounding rocket shots from Wallops Island in connection with International Year of Quiet Sun.

Nov. 16 week: External configuration of *Sprint* shown at Association of U.S. Army meeting in Washington, D.C.

—*Voyager* problems outlined at American Institute of Aeronautics and Astronautics in New York.

—Soviets reveal interest in helium as diluent gas during Second International Symposium on Bioastronautics and the Exploration of Space, San Antonio, Tex.

—General Dynamics concludes five-day test in which four subjects lived in a rotating chamber with no apparent ill effects.

Nov. 16: NASA launches first Project Luster payload on *Aerobee 150* from White Sands Missile Range; payload recovery held up by bad weather.

Nov. 21: *Scout* vehicle used to launch NASA's first double payload into the Earth's upper atmosphere, *Air Density* and *Injun* satellites.

Nov. 23 week: Navy starts $200-million program for development and exploitation of deep-submergence vehicles.

—Winner of Air Force's 487L Survivable Communications System is Westinghouse Electric Corp., with a $30.3-million bid.

—First-generation U.S. ICBM's will be completely phased out by 1965, DOD reveals.

Nov. 28: *Mariner IV* launched by NASA on eight-month mission to Mars.

Nov. 30: M/R Special Annual NASA issue.

—Soviet Union launches *Zond 2* Mars probe; some power trouble apparent.

Nov. 30 week: Navy decides to cancel its FY 1966 funding request for *Advanced Surface Missile System*, presumably because of development problems.

—Bids received at NASA's Manned Spacecraft Center for *Apollo* bioinstrumentation contract.

—Majority of NASA's Launch Support Equipment Engineering Div. will move from Marshall Space Flight Center to Kennedy Space Center by next

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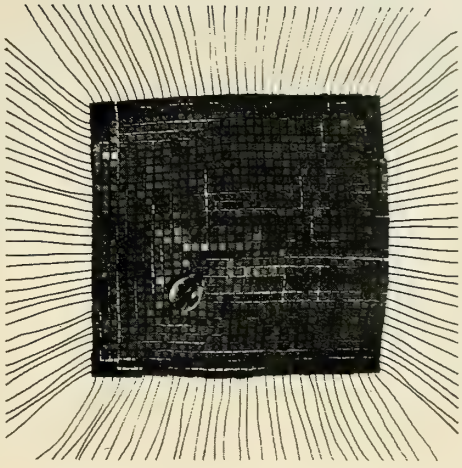

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summer, NASA announces. However, move has nothing to do with politics, Webb states.

—Midcourse correction to set *Mariner IV* on its way to Mars successful.

DECEMBER 1964

Dec. 1: Air Force launches *ABRES* ballistic re-entry system nose cone 5,000 mi. down Western Test Range from Vandenberg, AFB.

Dec. 4: Air Force's *Athena* rocket makes successful flight from Green River, Utah, to target area in White Sands Missile Range, N.M.

Dec. 7 week: Army's *Mauler* undergoes a successful test firing against target drone at White Sands.

—Communications Satellite Corp. and interested communications firms asked to submit detailed arguments concerning ownership and operation of initial ground stations for comsat system. Fight begins.

Dec. 8: *Apollo* boilerplate spacecraft undergoes perfect max Q test at White Sands.

—Fifth *ASSET* re-entry test vehicle in series of six from Cape Kennedy launched on single-stage *Thor*.

Dec. 9: *Titan II* launches vehicle carrying *Gemini II*, an unmanned shot; shuts down prematurely, damages pad.

Dec. 10: Air Force achieves first success in two launches of *Titan III-A* booster from Cape Kennedy.

—Tass announces Soviet Union launched *Cosmos 51*.

Dec. 11: Despite failure of engine to restart, NASA's launch of *Centaur* stage is said to have met all test objectives.

Dec. 14 week: Hawker Siddeley Dynamics and its partner Engins Matra awarded pact to build first *ESRO* satellite.

—*Manned Orbiting Laboratory* wins development okay; DOD reveals that program definition studies will begin soon.

Dec. 15: An all-Italian crew successfully launches Italy's *San Marco I* satellite from Wallops Island, Va., employing a NASA-supplied *Scout* booster. Italian team was first to conduct a foreign launch.

Dec. 16, 17: Seven meteorological probe vehicles launched from Pacific Missile Range, including the Navy's *Denpro II* and *III*, and first test of Air Force-developed *Frangible Arcas*.

Dec. 21: Launch of *Explorer 26*, 101-lb. satellite designed to study method of trapping radiation particles in Van Allen belt, orbits in elliptical path.

—Launch identified as "space probe" but believed to have been second successful launching of an Electro-Optical Systems, Inc.-developed contact cesium-ion engine by Air Force.

Dec. 28 week: ICBM cutback revealed in new defense budget approved by McNamara.

—Boeing Co. named systems integration contractor for NASA's three-stage *Saturn V* booster, under $85-million addition to its contract as prime for booster's first stage.

—Top NASA officials approve development of *Voyager* spacecraft for Mars exploration missions in 1971 and 1973.

JANUARY 1965

Jan. 4 week: Transfer of *Syncom II* and *Syncom III* communications satellite from NASA to DOD begun; to be completed around March 31.

—Space Detection and Tracking Radar system at Eglin AFB, Fla., totally destroyed in $30-million fire.

Jan. 11: Soviet Union launches *Cosmos 52*.

Jan. 12 week: *Transit*, Navy's navigational satellite system, declared operational by Defense Dept.

—Arthur D. Little report predicts gloom for defense industry unless it makes use of good management consultants.

Jan. 13: Mother-daughter payload fails to separate as planned, but Wallops Island-launched probes return good telemetry.

Jan. 15: Air Force *Athena* launch from Green River, Utah, termed "flawless" by Air Force.

Jan. 18 week: Navy going ahead with *Polaris B-3* or *Poseidon* missile, President Johnson announces.

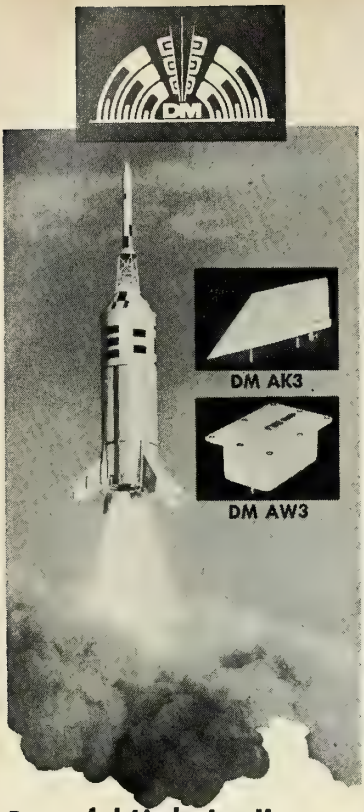
Jan. 19: *GT-2* ballistic shot near perfect, but marred by 25-second loss of communications.

Jan. 21: Air Force launches *Atlas* from Vandenberg with piggyback satellite to sample radiation and micrometeorites. First satellite to be orbited westward around Earth.

Jan. 26: Navy fires *Hydra-Iris* sea-launched rocket to 184-mi. altitude carrying 100-lb. payload, 1,400 miles east of Montevideo, Uruguay.

Jan. 30: Soviet Union launches new space booster that spanned more than 8,000 miles of the Pacific, according to Tass.

Jan. 31: Japan launches *Lambda III-2*, largest rocket country has yet developed. The 62-ft. three-stage rocket attained altitude of 620 mi. and impacted northwest of Mariana Islands some 1,130 mi. from launch site at Tokyo University's space center on Kyushu.



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FEBRUARY 1965

Feb. 1 week: GAO charges NASA mismanagement of *Nimbus* satellite resulting in unnecessary costs of $1.2 million.

Feb. 3: Air Force launches two *Minuteman* ICBM's in ripple-launch, both from silos and within minutes of one another.

Feb. 8: *PolarisA-3* successfully launched from USS Sam Rayburn nuclear submarine.

Feb. 8 week: North American Aviation repeats as top contractor with NASA in FY 1964.

—M/R Special Fluidics Report outlines market, technology.

Feb. 9: Air Force SAC crew successfully launches *Minuteman* ICBM from Vandenberg.

Feb. 11: *Titan III-A* performs as planned in launch from Eastern Test Range in major milestone on way to *Titan III-C* development.

Feb. 15 week: NASA reveals cancellation of Floxed *Atlas* program, consideration of uprating standard *Atlas SLV-3X* launch vehicle.

Feb. 16: *Saturn SA-9* successfully fired from Cape carrying *Pegasus* micrometeoroid satellite.

Feb. 17: *Ranger VIII* boosted from Cape aboard *Atlas* in apparent success.

Feb. 20: *Ranger VIII* sends back pictures from Moon.

Feb. 21: Soviet Union launches three *Cosmos (54, 55, 56)* satellites.

Feb. 22: Soviet Union launches another *Cosmos*, number *57*.

Feb. 22 week: Bids from seven firms received on preliminary design study of *Voyager* spacecraft.

Feb. 23: Sixth *Asset* re-entry vehicle launched from Cape Kennedy, but lost in ocean with important data.

Feb. 26: *HIBEX*, high-acceleration experimental missile booster sponsored by ARPA, successfully flight-tested at White Sands Missile Range.

Feb. 26: Soviet Union launches *Cosmos 58*.

Mar. 1 week: Four firms awarded preliminary design studies for *Manned*

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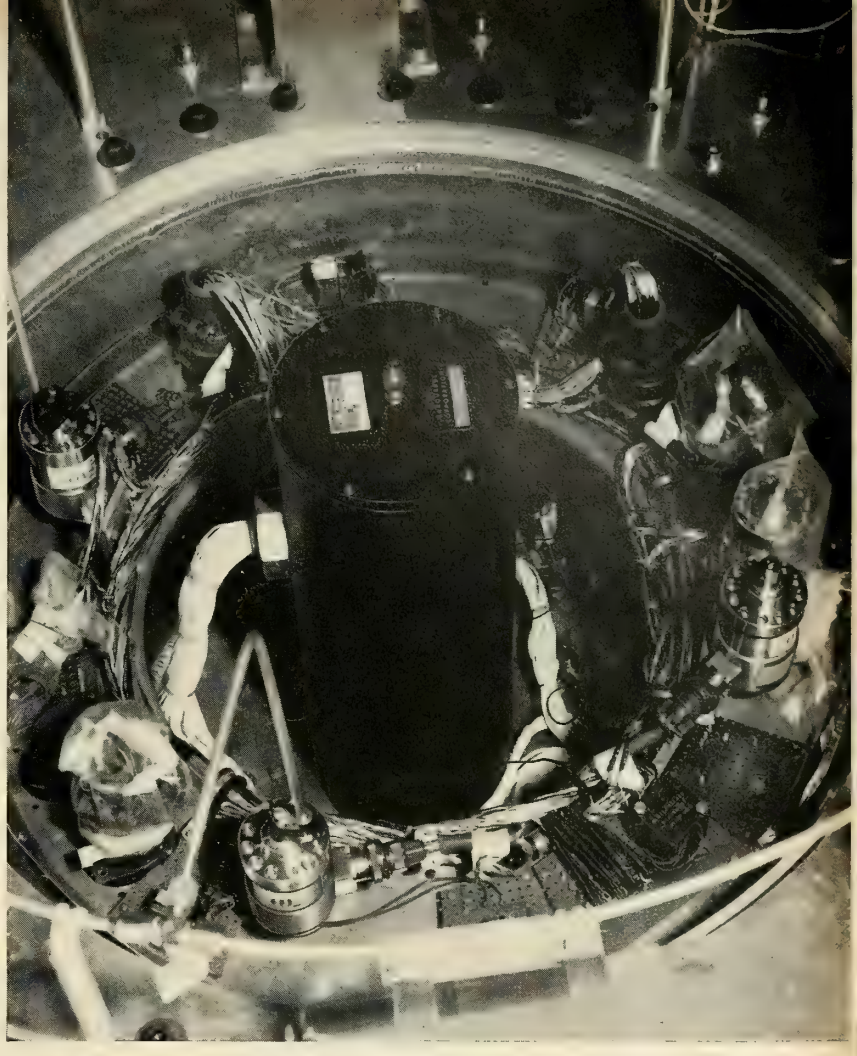

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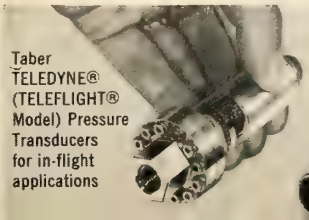

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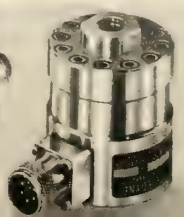

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Orbiting Laboratory—Boeing, Douglas, General Electric and Lockheed. Each study to last 60 days, cost $400,000.

—Martin SV-5 lifting body photographs revealed. Over 50 flights had been made in earliest version.

Mar. 2: *Atlas-Centaur 5* explodes and is destroyed on pad after vehicle, carrying dynamic model of *Surveyor*, settled back on launch pad when two *Atlas* first-stage engines cut off shortly after lift-off for no apparent reason.

Mar. 7: Soviet Union launches *Cosmos 59*.

Mar. 8: French launch *Emeraud* space satellite booster stage successfully after two previous failures. Shot made from Sahara.

Mar. 8 week: NASA awards Pratt & Whitney $19 mllion (estimated) two-year extension on development of RL-10 engine.

—First *Early Bird* communications satellite delivered to Cape.

—NASA asks Congress for approval of plans to reprogram 1965 funds to accommodate changes and overruns in a number of programs, and to close out or keep work going on 260-in. solid booster, M-1 and SNAP-8 programs.

—LTV Aerospace Corp. crew successfully fires Army's *Lance* tactical missile at White Sands Range, meeting all test objectives.

Mar. 15 week: Lockheed tops DOD contractors in FY 1964, chart shows.

—Air Force revealed drafting its own *Biosatellite* study contract with Lockheed.

Mar. 16: Robert H. Goddard Day.

—Two Air Force crews launch *Minutemen* from Vandenberg.

Mar. 18: Soviets launch *Voskhod II;* co-pilot Alexei Leonov makes first extra-vehicular space walk. Flight takes 26 hours, 17 orbits.

Mar. 21: *Ranger IX* launched from Cape Kennedy.

Mar. 22: Britain's *Blue Streak* successfully passes third firing in Woomera test.

Mar. 23: Successful *Ranger IX* mid-course correction made.

—*GT-3*, first manned *Gemini*, completes successful three-orbit flight.

Mar. 24: *Ranger IX* broadcasts TV pictures direct from the Moon in excellent flight before impacting on-target on the Moon. Pictures of highlands revise lunar-landing plans.

Mar. 26: Initial launch of *Sprint* missile by Army highly successful.

—Army announces recent interception near Kwajalein Island of simulated ICBM by two *Zeus* missiles fired seconds apart. Says more than 80% of *Zeus* firings to date have been partially or completely successful.

Mar. 30: Air Force uses *Blue Scout* to launch second of five planned cosmic radiation experiments from Cape Kennedy.

APRIL 1965

Apr. 3: SNAP 10A, first nuclear power system to be tested in space, reported functioning perfectly in orbit after *Agena* launch.

Apr. 5 week: Air Force shows pictures of satellite in space illuminated by laser beam.

Apr. 6: Communications Satellite Corp.'s *Early Bird* satellite launched by NASA in apparent success.

Apr. 9: Air Force scientists launch 30-lb. Mini-Lab experiment from Cape Kennedy aboard *Blue Scout* to study radiation effects on human tissue.

Apr. 12 week: NASA announces that

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—Aerojet-General fires sterilized solid JATO-type propellant previously subjected to three separate 36-hour temperature cycles at 292°F for sterilization.

—DOD approves plan to launch two unmanned *Gemini* test vehicles—recovered from NASA flights—in early phase of *Manned Orbiting Laboratory* program.

Apr. 14: Air Force loses first in series of *Stellar Acquisition Feasibility Flight (STAFF)* experiments from Cape Kennedy on *Polaris A-1* booster; vehicle veers off course and is destroyed.

Apr. 15: Army's *Lance* tactical missile undergoes second successful firing.

Apr. 19 week: Lunar Surface Symposium at Goddard Space Flight Center leaves scientists about where they were—disagreeing violently.

—New spacesuit design by Hamilton-Standard for *Apollo* mission disclosed.

—More than 100 delegates from Eurospace begin two-week conference and tour of U.S. aerospace installations with meeting in Philadelphia.

Apr. 23: Soviet Union launches first communications satellite, *Molniya I*, non-synchronous device similar to *Telstar I;* TV relayed.

Apr. 26 week: House Space Committee votes $5.183 billion for NASA FY 1966 authorization.

—*Voyager* preliminary spacecraft design study awards go to Boeing, General Electric and TRW/STL.

Apr. 29: NASA successfully orbits *Explorer 27, Beacon Explorer C,* from Wallops Island, Va.

MAY 1965

May 3 week: TV demonstrations begin using *Early Bird.*

—Soviets report *Zond II* Mars probe has stopped transmitting signals to Earth.

—House Armed Services Special Investigating Subcommittee begins probe of activities of Aerospace Corp.

May 6: Successful fourth start in space marks fourth launch of *Titan III-A* at Cape Kennedy. Final start sent Transtage from circular orbit to elliptical orbit.

May 7: ARPA announces *HIBEX* again successfully launched from White Sands.

—After weeks of delay, *Minuteman II* ICBM launched from Cape Kennedy.

—Soviet Union launches *Luna V* and *Cosmos 66. Luna* fails to soft-land as intended and crashes on Moon, apparently without taking pictures.

May 10 week: NASA and DOD approve uprated *Atlas SLV-3X* program.

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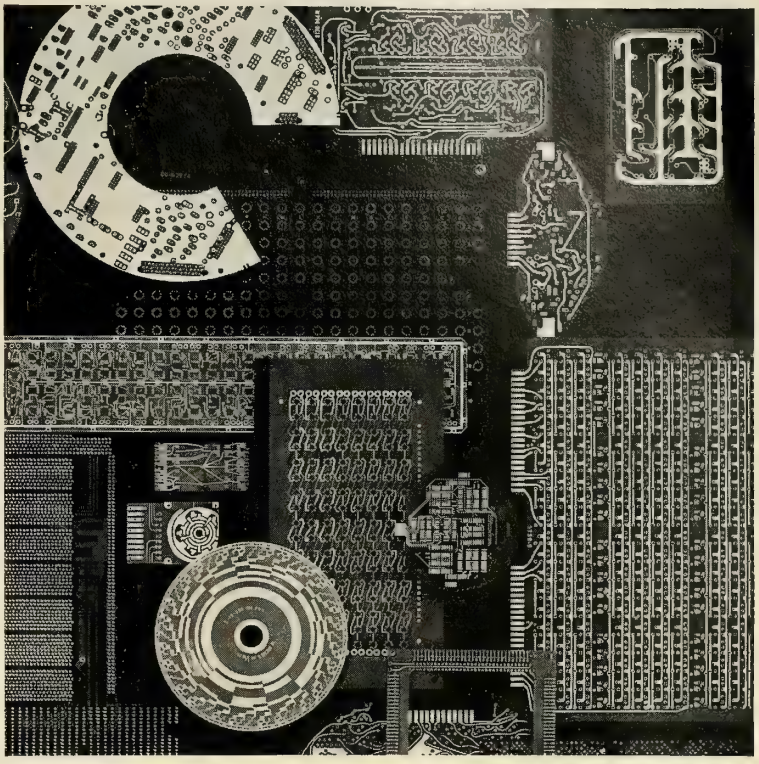

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—House Appropriations Committee cuts $100 million from NASA budget.

—Joint Committee on Atomic Energy cuts SNAP-50 program by $10 million.

—Soviets reveal new solid-fueled ICBM in *Improved Minuteman* class in VE-Day parade in Red Square.

—Shipboard firings of *Seaspar* missile begun off Point Mugu.

May 12: Air Force *Blue Scout* carries third in series of five cosmic radiation experiments from Cape Kennedy to learn about distribution of energy in inner radiation belt.

May 17 week: Hearings in which DOD and defense contractors charge General Accounting Office with meddling in contract affairs outside its jurisdiction continue in second week before House Military Government Operations committee.

—Gen. Bernard A. Schriever reveals advances in *Midas* system at Aviation/Space Writers Association.

—Cospar meeting held in Buenos Aires.

May 17: First production model of Army's *Roadrunner*, low-level version of *Redhead Roadrunner*, fired in perfect test.

—French announce second successful test flight of *Emeraude* with mockup of *Topaze*.

May 19: NASA uses *Javelin* rocket to loft "mother-daughter" payload for ionospheric measurements from Wallops Island, Va.

—*Apollo* launch escape system passes unintentional test when *Little Joe II* booster flies apart at 15,000 ft. Launch was to have tested system at 112,000 ft.

May 20: *NERVA* nuclear reactor runs at full power for 13 minutes, then is restarted.

May 22: NASA scores major success with launch of Project *Fire* re-entry experiment from Cape Kennedy.

May 24 week: Extravehicular experiment given go-ahead for *GT-4* flight.

—DOD said to be stepping up weather satellite work with Joint Meteorological Satellite Program Office (JMSPO).

May 26: Army artillerymen successfully fire *Pershing* ballistic missile from Gilson Butte, Utah, into White Sands Missile Range some 400 mi. away.

May 29: *Explorer 28*, latest *Interplanetary Monitoring Platform*, successfully set into orbit by *Delta* launch vehicle.

May 31: Sandia Corp. launches four *Nitehawk* rockets from Cook Island in South Pacific to make observations of solar eclipse.

May 31: M/R Special Electronics Research Center issue.

May 31 week: Government Operations Committee of House urges DOD to commence full-scale development of *Manned Orbiting Laboratory* without further delay.

JUNE 1965

June 3-7: *GT-4* orbits Earth in dramatically successful flight. Astronaut White makes record extravehicular space walk, using propulsion gun.

June 7 week: NASA terminates $6.7-million 260-in. solid rocket demonstration with Thiokol Chemical Corp. because of rupture in motor case in hydrotest.

—North American Aviation again leads list of NASA top contractors for first half of FY 1965.

—Air Force publicly confirms a number of ballistic missile improvement efforts now underway, including *Minuteman* and *Titan II*.

June 8: Air Force launches fifth and last in a series of cosmic radiation experiments from Cape Kennedy aboard four-stage *Blue Scout*.

—Soviet Union launches sixth *Luna* in path intended to take it to Moon, presumably to soft land. However, midcourse correction maneuver goes awry and craft hurtles past Moon, missing it by some 100,000 mi.

—Air Force launches *ABRES* re-

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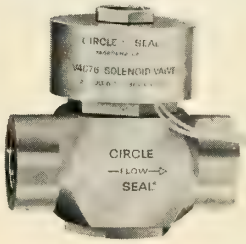

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entry experiment aboard *Atlas* booster from Vandenberg.

June 12: Canada's *Black Brant* has first successful test from Ft. Churchill, Manitoba.

June 14 week: NASA authorization bill reaches final action. Conference between House and Senate space committees irons out differences in two bills, and sets final amount at $5.19 billion.

—Lockheed Missiles and Space Div. selected by Atomic Energy Commission for negotiations as SNAP 25 contractor.

—Five F-1 engines of *Saturn V* fired successfully for 90 sec.

June 15: Air Force launches second of four *Stellar Acquisition Feasibility Flight (STAFF)* shots from Cape Kennedy, meeting all test objectives.

June 16: Poland launches its first meteorological rocket, two-stage vehicle reaching 37,000 meters.

—*Pershing* tactical missile successfully fired from Gilson Butte to White Sands.

June 17: Army successfully fires its in-house-developed version of new *Medium Anti-tank Weapon (MAW)* at Redstone Arsenal.

—Two air-to-air missiles, presumably *Sidewinders* or *Sparrows*, bring down two North Vietnamese MIG-17 fighters 40 miles south of Hanoi.

June 18: *Titan III-C* a complete success in Cape Kennedy launch.

—Canada's *Black Brant* undergoes second successful launch at Ft. Churchill, Manitoba.

—Air Force resumes tests of *Athena* re-entry program with two shots.

—New research rocket, *Aerobee 350*, initiated in first Wallops Island launch.

June 21 week: Astronauts White and McDivitt travel to Paris to Air Show to recoup lost prestige in U.S. effort there.

—House votes to cut $30.7 million in *SRAM* funding, in action on $45.2 billion Defense Appropriations bill.

—SNAP 10A and SNAP 50 cut in House Public Works Appropriations bill.

—Air Force Capt. Joe Engle flies *X-15* rocketplane to altitude of 282,000 ft. (over 50 mi.), qualifying him for military astronaut rating.

June 28 week: Selection of six scientist-astronauts announced by NASA.

—Commercial satellite communications between U.S. and Europe begun with call via *Early Bird* from President Johnson to government leaders in Europe.

—Senate Appropriations Committee votes NASA $10 million to adapt *Titan III-C* for *Surveyor* in reporting NASA appropriations bill.

June 29: Second *Apollo* pad abort test conducted at White Sands Missile Range termed full success.

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Status Of FY 1966 Budgets

Dept. of Defense Appropriations

Figures in parentheses show amount by which House increased or decreased original DOD request.

MILITARY PERSONNEL

TOTAL—MILITARY PERSONNEL . . $14,565,600,000

OPERATIONS AND MAINTENANCE

Operations and Maintenance, Army 3,475,200,000

Reductions were made in the following categories:
Special training and enlistment program . . . . . (500,000)
Air transportation rates . . . (1,000,000)
Communications . . . . . (7,000,000)
Field exercises . . . . . (21,835,000)
Increases were granted in the following categories:
Unspecified higher priority needs 30,335,000

Operations and Maintenance, Navy 3,332,100,000

Reductions were made in the following categories:
Long Beach Hospital . . . . . (494,000)
Air transportation rates . . . (1,000,000)
Communications . . . . . (5,000,000)
Increases were granted in the following categories:
For higher priority needs, unspecified 6,494,000

Operations and Maintenance, Marine Corps 192,500,000

Operations and Maintenance, Air Force 4,464,100,000

Reductions were made in the following categories:
Air transportation rates . . . . . (3,300,000)
Field exercises . . . . . (64,121,000)
Increases were granted in the following categories:
Unspecified higher priority needs 67,421,000

Operations and Maintenance, Defense Agencies . . . 533,762,000

Operations and Maintenance, Army National Guard . 208,800,000

Operations and Maintenance, Air National Guard . 238,000,000

National Board for the Promotion of Rifle Practice, Army 459,000

Claims, Defense 24,000,000

Contingencies, Defense . 15,000,000

Court of Military Appeals, Defense 579,000

Appropriation to liquidate contract authorization; O&M Army FY1962 54,044,000

Deficiency appropriation, medical care, Navy, FY1958 8,600,000

TOTAL—OPERATIONS AND MAINTENANCE 12,547,144,000

PROCUREMENT

Procurement of Equipment and Missiles, Army 1,205,800,000

Reductions were made in the following categories:
Communications and

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electronics ..... (7,200,000)
Program changes reported by Army ..... (10,100,000)
Common ground equipment ..... (5,200,000)
M-60 tank and equipment ..... (6,500,000)
ARAAV, long leadtime components ..... (8,900,000)
HE projectiles ..... (12,800,000)
Increases were granted for:
Shillelagh missiles 23,300,000

Procurement of Equipment and Missiles, Navy .. 2,272,500,000

Reductions were made in the following categories:
F-4 aircraft ..... (6,900,000)
F-111B aircraft ..... (4,200,000)
A-7A aircraft ..... (4,400,000)
F-4J aircraft, advance procurement ..... (5,900,000)
F-111B aircraft, advance procurement ..... (5,300,000)
CH-46A helicopter, advance procurement ..... (2,500,000)
Aircraft items, less than $2 million each ..... (1,700,000)
UGM-27C missile ..... (7,100,000)
Fleet support ..... (3,900,000)
Missile items, less than $2 billion each ..... (400,000)
Additional financing by recoupments ..... (6,700,000)
Increases were granted in the following categories:
Program changes reported by Navy 10,500,000
A-6A aircraft 6,300,000
A-7A aircraft, advance procurement 11,800,000
CH-46A helicopter 9,100,000
UH-46A helicopter 3,000,000
TA-4E aircraft 8,100,000
TA-4E aircraft, advance procurement 3,400,000

Shipbuilding and conversion, Navy ... 1,590,500,000

Reductions were made in the following categories:
Fast deployment logistic ships ..... (64,200,000)
Increases were made in the following categories:
Attack submarines (SSN) .. 133,600,000
DLGN, advance procurement 20,000,000

Other procurement, Navy 1,120,000,000

Reductions were made in the following categories:
Communications and electronics ..... (9,400,000)
Unspecified reductions through tightening of procurement ..... (29,900,000)
AN/SQQ-16 ..... (700,000)
ASWEPS ..... (1,600,000)
AN/SLQ-14 (SN-1) buoy ..... (2,500,000)
Mine, MK 56 ..... (700,000)
Mine, MK 57 ..... (900,000)
ASROC rocket (less payload) ..... (1,400,000)
Torpedo MK 46 ..... (10,900,000)
Sonobuoys ..... (2,800,000)
BDU practice bomb ..... (1,100,000)
Increases were granted in the following categories:
Program changes reported by Navy 200,000
Mine support 1,500,000
Torpedo MK 37 1,000,000
Torpedo MK 48 8,500,000
Torpedo support 1,000,000

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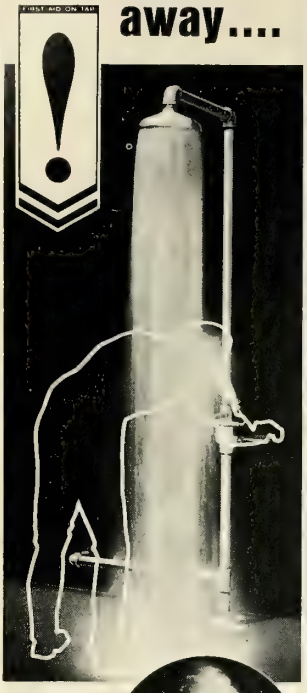

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Fire control and launching equipment (misc.) 800,000
Torpedo MK 48 FCS training equipment 500,000
AN/TSQ-18 radar surveillance control gp. 2,200,000
Items less than 500,000 each (CE support equipment) 3,100,000
Amphibious and specialized equipment 1,100,000
Miscellaneous items 1,300,000

Procurement, Marine Corps 43,800,000

Aircraft procurement, Air Force 3,517,000,000

Reductions were made in the following categories:
F-4 aircraft ..... (19,600,000)
F-111 aircraft ..... (13,600,000)

Missile procurement, Air Force 796,100,000

Other procurement, Air Force 829,100,000

Reductions were made in the following categories:
Communications and electronics ..... (10,000,000)
Space track equipment ..... (5,700,000)
Increases were granted in the following categories:
Program changes reported by Air Force 4,600,000
20mm. HEI M/61/M14 Link 10,300,000

Procurement, Defense Agencies 15,200,000

Reductions were made in the following categories:
Communications and electronics ..... (200,000)
Additional financing by recoupments ..... (8,600,000)

TOTAL—PROCUREMENT 11,390,000,000

RESEARCH, DEVELOPMENT, TEST AND EVALUATION

Research, Development, Test and Evaluation, Army 1,406,400,000

Reductions were made in the following categories:
Behavioral and social sciences .. (500,000)
Human factors research ..... (1,000,000)
Unspecified military sciences projects ..... (15,500,000)
Federal contract research centers ..... (2,000,000)
Other equipment, RDT&E ..... (6,000,000)
R&D for a classified installation ..... (6,600,000)

Research, Development, Test and Evaluation, Navy 1,439,200,000

Reductions were made in the following categories:
Behavioral and social sciences .. (500,000)
Unspecified military sciences projects ..... (19,200,000)
Advanced surface-to-air missile program ..... (10,000,000)
Integrated light attack avionics ..... (3,700,000)

Research, Development, Test and Evaluation, Air Force 3,103,900,000

Reductions were made in the following categories:
Behavioral and social sciences .. (500,000)
Unspecified military sciences projects ..... (9,700,000)
Short Range Attack Missile (SRAM) ..... (30,700,000)
Financing proposed by additional recoupments from XB-70 ..... (10,000,000)
Increases were made in the following categories:

Advanced manned strategic aircraft (AMSA)	7,000,000
Research, Development, Test and Evaluation, Defense Agencies	**495,000,000**
Reductions were made in the following categories:	
Behavioral sicences, ARPA	(500,000)
Unspecified reduction	(4,900,000)
Emergency Fund, Defense*	**150,000,000**

*Provision is made for $150,000,000 additional to be derived by transfer from other DOD appropriations and $200,000,000 to be available by transfer under provisions of the appropriations act.

TOTAL—RESEARCH, DEVELOPMENT, TEST AND EVALUATION	6,594,500,000
TOTAL—ALL DOD AGENCIES	45,188,244,000

RECAPITULATION

Department of the Army	**10,963,903,000**
Department of the Navy	**13,942,200,000**
Department of the Air Force	**17,519,600,000**
Defense Agencies	**2,762,541,000**
TOTAL—DEPARTMENT OF DEFENSE	$45,188,244,000

NASA FY '66 Authorization

(in thousands of dollars)

RESEARCH & DEVELOPMENT AUTHORIZATION	**$4,536,971**

OFFICE OF MANNED SPACE FLIGHT	**3,219,485**
Gemini Program	**242,100**
Spacecraft	122,700
Launch vehicles	88,600
Support	30,800
Apollo Program	**2,967,385**
Spacecraft	*
Saturn I	*
Saturn IB	*
Saturn V	*
Engine development	*
Apollo mission support	*
Advanced Missions Program	**10,000**
Advanced missions program	10,000

OFFICE OF SPACE SCIENCE AND APPLICATIONS	**773,015**
Physics and Astronomy Program	**165,900**
SR&T	25,200
Solar observatories	37,000
Astronomical observatories	26,300
Geophysical observatories	31,700
Explorers	25,700
Sounding rockets	17,000
Data analysis	3,000
Lunar and Planetary Exploration Program	**213,115**
SR&T/Advanced studies	36,800
Ranger	1,415
Surveyor	84,100
Lunar Orbiter	36,000
Mariner	3,800
Voyager	43,000
Pioneer	8,000
Sustaining University Program	**46,000**
Training	25,000
Research facilities	8,000
Research	13,000
Launch Vehicle Development Program	**63,000**
SR&T	4,000
Centaur development	59,600
Launch Vehicle Procurement Program	**178,700**
Scout	*
Delta	*
Agena	*
Centaur	*
Bioscience Program	**31,500**
SR&T	15,500
Biosatellite	16,000
Meteorological Satellites Program	**42,700**
SR&T	8,200
Meteorological flight experiments	4,000
Tiros	4,800
Nimbus	22,700
Meteorological soundings	3,000

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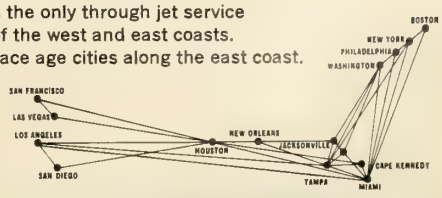

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SR&T	2,500
Relay	200
Syncom	100
Applications Technology Satellites Program	**28,700**
SR&T	2,000
Applications technology satellites	26,700

OFFICE OF ADVANCED RESEARCH AND TECHNOLOGY	**297,400**
Basic Research Program	**22,000**
SR&T	22,000
Space Vehicle Systems Program	**35,000**
SR&T	24,000
Project FIRE	500
Scout re-entry project	5,000
Lifting body flight and landing tests	1,000
Pegasus	2,500
Small space vehicle flight experiments	2,000
Electronic Systems Program	**34,400**
SR&T	30,000
Small flight projects	4,400
Human Factors Systems Program	**14,900**
SR&T	13,000
Small biotechnology flight projects	1,900
Nuclear-Electric Systems Program	**33,000**
SR&T	24,000
SNAP-8	6,000
Space Electric Rocket Test (SERT)	3,000
Nuclear Rockets Program	**58,000**
SR&T	22,000
NERVA	35,000
Nuclear Rocket Development Station	1,000
Chemical Propulsion Program	**43,700**
SR&T	30,000
M-1 engine	7,500
260-in. solid motor	6,200
Solar and Chemical Power Program	**14,200**
SR&T	14,200
Aeronautics Program	**42,200**
SR&T	8,300
X-15A research aircraft	900
Supersonic transport	16,000
V/STOL aircraft	2,000
Hypersonic ramjet experiment	5,000
XB-70/SST flight research project	10,000

OFFICE OF TRACKING AND DATA ACQUISITION	**242,321**
Tracking and Data Acquisition Program	**242,321**
Operations	125,421
Equipment	102,400
SR&T	14,500

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Technology Utilization Program **4,750**

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Regional information dissemination projects	*
Analysis of technology transfers; research and development management; the long-range implications of the space program	*

CONSTRUCTION OF FACILITIES AUTHORIZATION 62,376.35

Ames Research Center **2,749**

S-Systems engineering facility	2,749

Electronics Research Center **5,000**

R-Space guidance laboratory	*
R-Optical communications laboratory	*
R-Microwave radiation laboratory	*
R-Center support facilities (second phase)	*

Goddard Space Flight Center **2,400**

S-NASA space science data center	2,000
S-Utility installation	400

Kennedy Space Center **8,195**

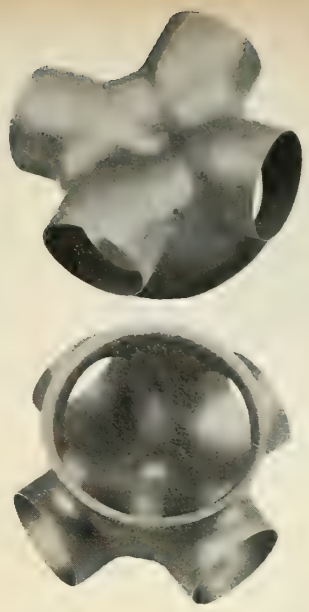
M-RF systems test facility	*
M-Flight crew training building extension ...	*
M-Extension to the medical facility	*
M-Utility installations (new area)	*
S-Modifications to Launch Complex 17 ...	1,300

Langley Research Center **8,250**

R-Flight control facility	3,576
R-Life support technology laboratory	2,492
R-Increased capabilities of 20-in. Mach 6 and Mach 8.5 tunnels	682
R-Magazine and test areas for highly reactive chemical mats	1,500

Lewis Research Center **867**

R-Building addition to the 10 x 10-ft. supersonic wind tunnel for data processing	407
R-Space power research laboratory	460



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Manned Spacecraft Center	**4,180**
M-Modifications to the environmental testing laboratory	*
M-Center support facilities	*
Marshall Space Flight Center	**2,309.45**
M-Non-destructive testing laboratory	672.6
M-Additions to materials laboratory	1,051.65
M-Test engineering building extension	585.2
M-Extension to high pressure gas systems	—
M-LOX storage facilities for west test area	—
Michoud Plant	**284.75**
M-Improvements to the storm drainage system	284.75
Mississippi Test Facility	**1,910.45**
M-Addition to S-II stage checkout and storage building	1,118.15
M-General support facilities	792.3
Various locations	**20,182.70**
M-Facilities for F-1 engine program	*
M-Facilities for J-2 engine program	*
M-Facilities for S-II stage program	*
T-Apollo wing, Madrid deep space facility	472
T-Apollo wing, Canberra deep space facility	510
T-STADAN facility expansion	1,115
T-Apollo network ground station, Antigua, W.I.	2,500
T-Community support facilities	2,090
T-Apollo network ground station, Grand Canary Islands	7,674
Wallops Station	**1,048**
S-Launch control building	605
S-Assembly shop	443
Facility Planning and Design	**5,000**
ADMINISTRATIVE OPERATIONS AUTHORIZATION	**591,048.85**
TOTAL AUTHORIZATION	$5,190,396

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An Assessment

THE INCREASED PACE of U.S. and Soviet space activity is evident in daily newspaper headlines about *Mariner IV, Proton I, Zond III, GT-5, Titan III-C* and any number of related vehicles, yet to be launched or already on the record books.

Less prominent in the public eye but still significant are *Blue Streak, Diamant* and the European satellite and launcher programs. All of these add to the burgeoning space effort evident in the pages of this annual world encyclopedia issue.

The year 1965, predictably, is an active one in missiles and space. But in comparing it with last year, a number of important developments stand out:

- The demonstration of the giant stride forward in Soviet booster capability shown by the *Proton I* launch.
- The Russian disclosure at the May 9 parade in Moscow that the long effort to master solids technology is at last paying off.
- The continuing U.S. vacillation on a military manned space program.
- The exciting progress in both U.S. and Soviet manned space flights, with extravehicular activity this year opening the door to projects of great potential.
- The establishment of an important new Air Force launch capability with the initial success of *Titan III-C*.
- *Mariner IV's* demonstration that even photographs that look like snapshots of a ball of yarn taken from ten feet away are of worldwide scientific and propaganda interest—if they happen to be the first such photographs of that particular ball of yarn.
- The growing importance of satellites in the more mundane fields of communications, navigation, geodesy and meteorology.

To assess the long-run impact of the year's developments from such a list is difficult. But certainly the continuing demonstration of Soviet missile/space competence illustrated by the first two items stands out in contrast to the irrational U.S. attitude evident in the third.

The remarkable record of the U.S. *Saturn* booster, together with the progress of *Titan III-C*, has resulted in dangerous complacency. For reasons we never have been able to fathom, many in positions of responsibility have assumed that Soviet booster technology has been dormant during this period of U.S. progress. To his credit, *Saturn* developer Dr. Wernher von Braun is not among these. He has warned repeatedly that larger Russian boosters were in the offing.

So has this magazine. Nearly three years ago (M/R, Aug. 20, 1962, p. 46), we predicted that the Soviet Union would unveil a booster superior to *Saturn* before the U.S. launch vehicle became operational. At that time, we asked: "Are we naive enough to believe that the Soviets are standing docile in booster technology while we overtake them enroute to the Moon?"

To those indeed that naive, the *Proton I* launch July 16 was a shock. The new Soviet vehicle inserted a working payload of 26,000 pounds into orbit, exclusive of the weight of the final stage of the booster. *Titan III-C* on June 18 put a payload of 21,000 pounds of lead into orbit. *Saturn SA-5* on Jan. 29, 1964, boosted 37,700 pounds into orbit but that included 11,700 pounds of sand and the S-IV second stage.

Discounting the merits of a working payload relative to sand and lead, the Soviet launch showed the Russians still well ahead of the U.S. in the race to develop manned space stations and a lunar landing capability.

Combined with the progress in solids indicated in the most recent Red Square parade of missile might, this might seem to raise some serious questions about just what is happening in Soviet booster technology. Not, of course, with Secretary of Defense McNamara, who continues to assure the nation that the Russians have no capability in solid-fueled ballistic missiles.

FOR THE PAST FIVE YEARS, advocates of big solids have pointed out that the U.S. has been frittering away a significant lead over the Soviets in this field. Certainly, U.S. exploration of big solids has been minimal. The assumption apparently has been that the Russians were incompetent in solid technology. But it now appears that the Soviets have employed this period to their advantage. They have displayed two naval missiles, two intermediate missiles and two strategic missiles, all of which are stated to be solid-fueled. The commanding lead the U.S. possessed as a result of its superior chemical technology has been significantly reduced. How far the Russians will carry this work is unknown, but the past record indicates they are exploring the solids potential at a greater rate than is the U.S.

Mr. McNamara's complacency about Soviet propulsion technology is on a par with his equanimity about the military importance of space. Presumably, only a Russian demonstration of the military value of space can really light a match under U.S. efforts.

Achievements in commercial satellites and scientific interplanetary probes are magnificent pluses on the U.S. record of the past year. But unless they are matched by intelligent application of time and money in areas that now are neglected, U.S. space accomplishment may not look as bright in comparison at this time next year.

There is an axiom in business that when you don't know what your competitor is up to, the wisest procedure is to give him credit for maximum accomplishment. Unfortunately, the Defense Dept. continues to underrate the space capabilities of the Soviet Union.

William J. Coughlin

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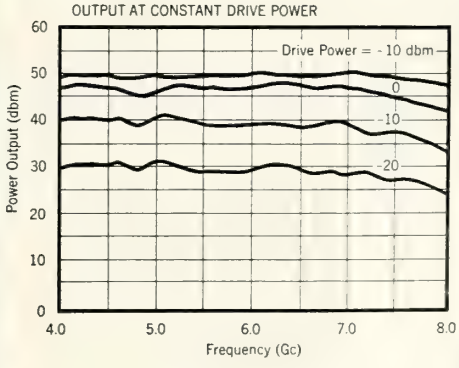

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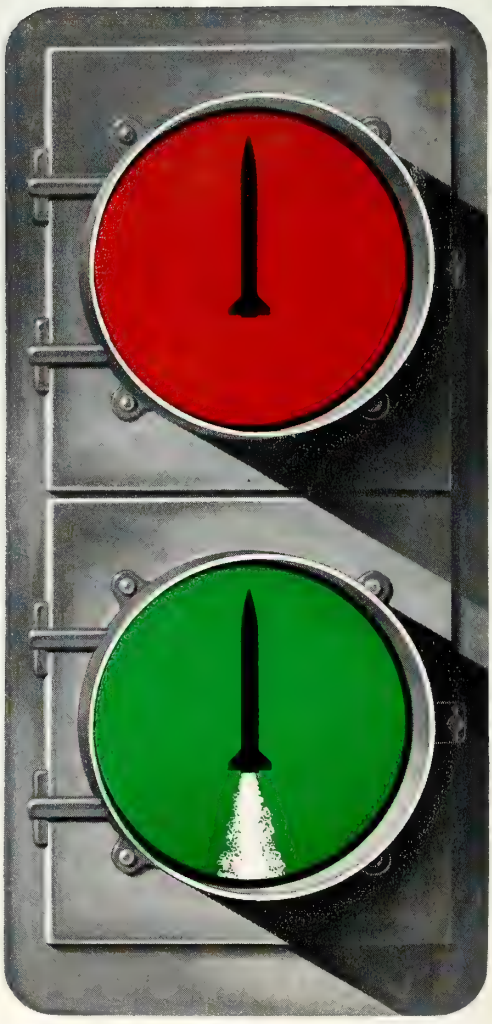

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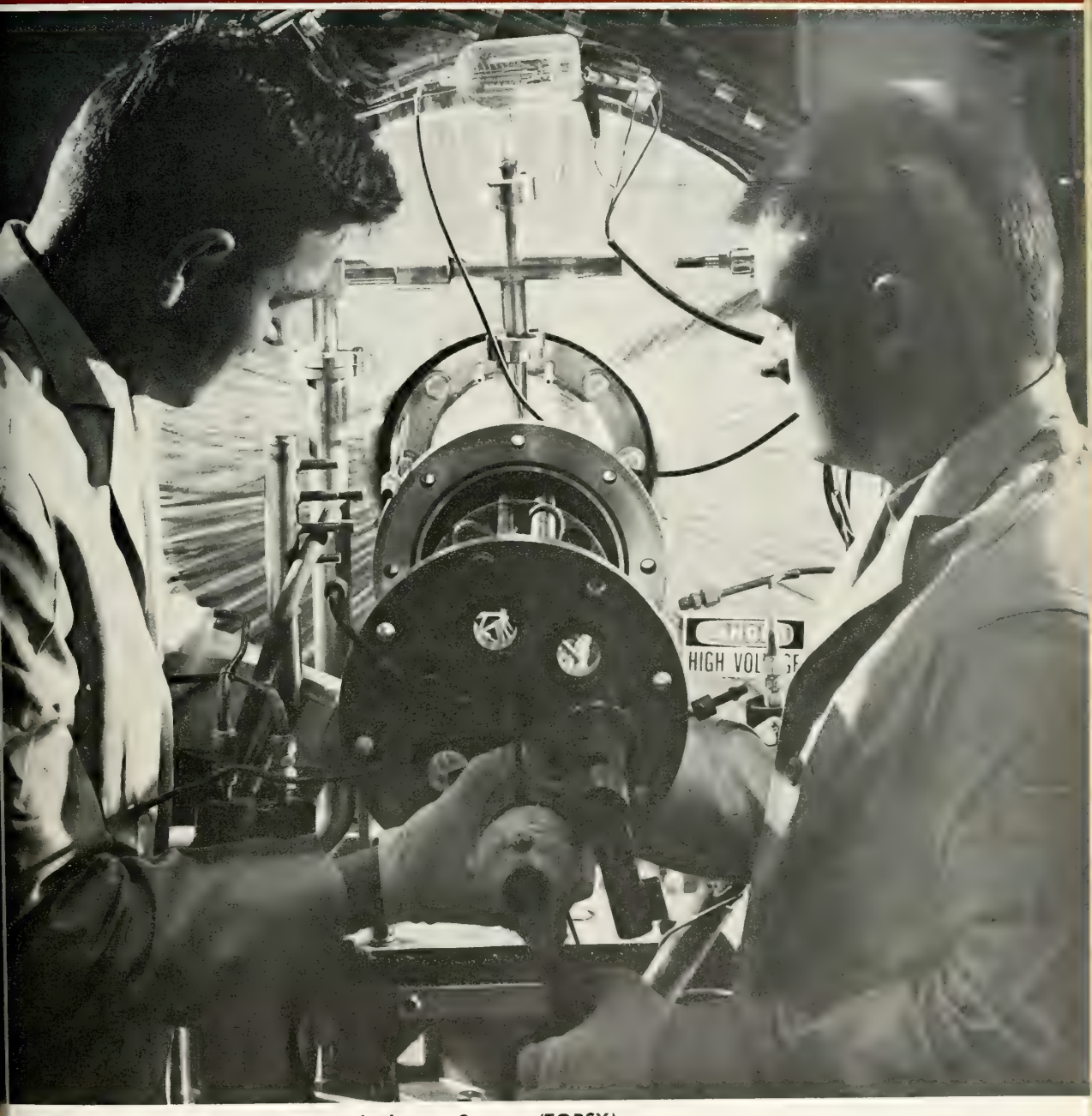

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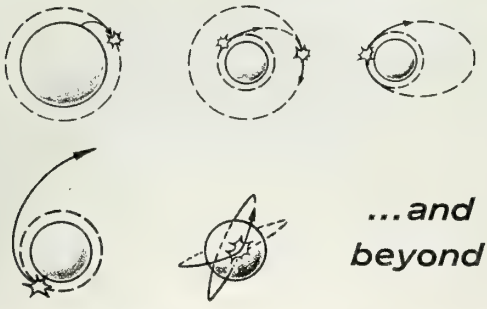

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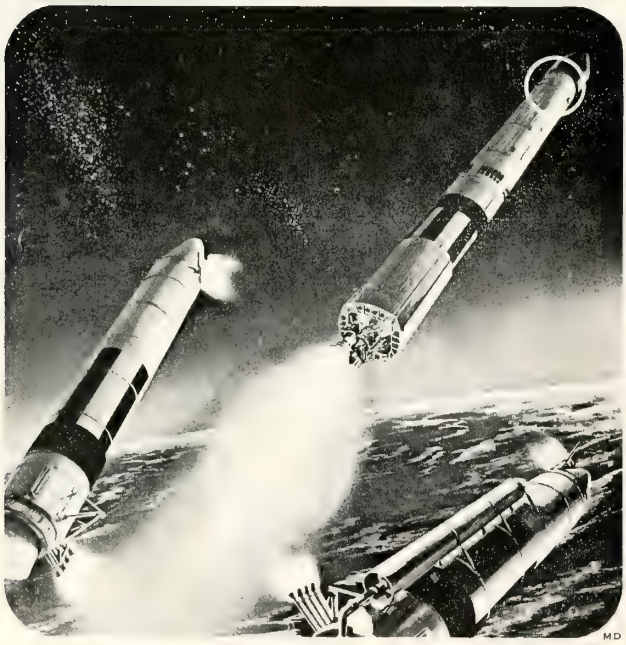

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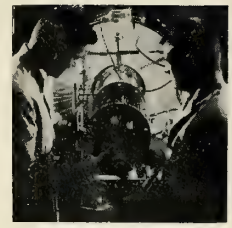

Scientists check the thermally operated plasma system (TOPSY) at Sperry Rand's research center, Sudbury, Mass. Work with the unit will be to simulate and measure micro-instabilities associated with high-temperature turbulent plasmas resulting from thermonuclear fusion reactions. See story, page 36.

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letters

X-Ray Astronomy

To the Editor:

M/R's report on the recent COSPAR meeting in Argentina (May 24) erred in attributing to British scientists the X-ray photographs of the Sun that showed limb brightening in the equatorial zone and bright spots at plages. In fact those photographs were obtained by Ricardo Giacconi and his associates at American Science and Engineering, Inc., in collaboration with John Lindsay at the Goddard Space Flight Center. They used image-forming grazing incidence-reflecting X-ray telescopes that were first developed at AS&E, and they launched their equipment on an *Aerobee* rocket with a solar-oriented instrument platform. Resolution of the X-ray photographs was limited by the jitter in the orientation mechanism to about one minute of arc. Several photographs were obtained with exposures ranging from 10 to more than 100 seconds. Dr. Giacconi reported these results at the COSPAR meeting.

The photographs of the Sun that were shown by the British scientists at the COSPAR meeting were obtained with a pinhole camera, as were the earlier ones obtained by the Naval Research Laboratory group. The pinhole pictures do not show the significant X-ray features revealed in the AS&E-Goddard photographs.

It is worth emphasizing that the development of the image-forming X-ray telescope is a very significant step in the development of X-ray astronomy because it provides an enormous increase in speed and resolution for the analysis of the structure of X-ray sources. Discovery of the equatorial solar X-ray corona is the first fruit of this development.

George W. Clark
Professor of Physics
Massachusetts Institute of Technology
Cambridge, Mass.

Mariner IV Model

To the Editor:

We were pleased to see the cover of your July 12 issue. We feel, however, that some explanation of the cover, and the item describing it on page 3, would be of interest to your readers.

The half-scale model of *Mariner IV* was built as part of a research project sponsored by the Office of Advanced Research and Technology of NASA, Space Vehicle Environmental Factors Branch, being conducted by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with Arthur D. Little, Inc., Cambridge, Mass.

The purpose of this project is to determine whether it is possible to build, at approximately half-scale, a thermal model of an actual spacecraft which, in solar-thermal-vacuum conditions, would predict accurately the behavior of the prototype. A paper describing an earlier phase of this work was to be presented at the AIAA Second Annual Meeting and Technical Demonstration in San Francisco last week by Mr. Frank Gabron, the director of the task at Arthur D. Little, Inc., and by Dr. J. M. G. Vickers, the Jet Propulsion Laboratory cognizant engineer for the project.

The contract between JPL and Little specifically stated that any tests of this model should not be carried out in the JPL chambers, since JPL wished to compare results obtained during the contract with later tests to be carried out at JPL. Little arranged with NASA-Lewis Research Center for the use of their chamber. The tests at Lewis were conducted by Mr. Gabron in the presence of Drs. Vickers and J. W. Lucas, as JPL representatives. Lewis provided valuable assistance by operating the chamber during this period. The tests were run at a vacuum of 10^{-6} mm mercury and with the chamber shrouds at liquid nitrogen temperatures. As indicated on (your) page 3, the Lewis chamber is capable of operating at a pressure of 10^{-12} mm mercury (with liquid-helium-cooled shrouds); however, in this instance the full capability was not used.

It should also be noted that the work of this project bears no direct relationship to *Mariner IV,* as might be implied by the reference to page 11 on page 3 of your magazine. *Mariner IV* was chosen as the prototype because there existed, at the time the contract was under consideration, a wealth of ground test data, and there was every hope that flight data would be available at the start of the research test phase recently completed.

We received a great deal of assistance from JPL personnel responsible for the temperature control of *Mariner IV,* but at no time were the results of this research project incorporated into the thermal design of *Mariner IV.* We would like to express our thanks to these people for the information which they supplied on their design, and to the personnel at Lewis who worked hard to provide us with the chamber conditions which we had specified to Little for the tests.

M. E. Alper
Section Chief, Applied Mechanics Section
J. W. Lucas
Research Group Supervisor
J. M. F. Vickers
Research Specialist
Project Cognizant Engineer
Jet Propulsion Laboratory
Pasadena, Calif.

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The Countdown

WASHINGTON

MOL Still in Abeyance

Decision on the *Manned Orbiting Laboratory* is at least another week away, according to U.S. officials. Alluding to the manned spacecraft in the context of the current Viet-Nam situation, they call it "the last thing on our mind at the moment." One source says recommendations have yet to be received from the Air Force and a decision has not been made.

Launch Office Switch to Follow Goett Transfer

Transfer of Goddard Space Flight Center's launch operations offices at both the Western and Eastern Test Ranges to the jurisdiction of the Kennedy Space Center is expected to be announced in the near future. Disagreement with NASA Administrator James E. Webb over this, over a proposed reorganization of Goddard, and over other matters played a role in the replacement of Harry Goett as GSFC director. He has now become a special assistant to Webb. Dr. John F. Clark, formerly associate director of sciences in the Office of Space Sciences and Applications, has become acting director of Goddard.

How Step-Up in Viet-Nam Will be Funded

Following President Johnson's press conference last week announcing stepped-up U.S. participation in the Vietnamese war, a U.S. official said Congress would be asked to amend the current military appropriations bill to add $1-2 billion for procurement of equipment and construction. He cited sections of the bill already providing ample authority for deficiency appropriations to cover personnel and Operations & Maintenance categories, and noted that Congress will be asked in January for a supplemental appropriation to the FY 1966 military budget, the exact amount and nature to be determined after Pentagon study. Most of the extra funds will go for procurement of helicopters, aircraft and additional ordnance.

Circumlunar Mission Stirs Little Thought

Dr. George E. Mueller's first reaction to a proposal to send a *Gemini* spacecraft on a circumlunar mission was that it would cost too much and wouldn't really accomplish anything. This was the comment of the NASA Associate Administrator for Manned Space Flight following presentation of the proposal by Marshall Space Flight Center. Later, McDonnell Aircraft Corp. and the Martin Co. urged that a *Titan III-C* be used to put two Transtages into orbit, to be followed by a *Gemini* which would rendezvous with the orbiting stages. The one unexpended Transtage would next be used for the six-day trip around the Moon. How much the new proposal differs from Marshall's and whether Mueller has changed his earlier opinion is not known. NASA simply says it is not seriously considering the latest proposal.

Next Gemini Launch Components Gather

The *Gemini 6* spacecraft and its *Titan II* launch vehicle are scheduled to be delivered to Cape Kennedy within a few days. They will join the target *Agena* upper stage, to be employed during the flight this fall, which arrived at the Cape on July 26.

NASA May Use Titan III-C—If . . .

A space agency official reports that NASA will fund some contractor effort in studying possible use of *Titan III-C* as a back-up launch vehicle for the *Surveyor* spacecraft—if money is voted by Congress. The Senate Appropriations Committee approved about $10 million for a back-up effort, but a joint House-Senate Appropriations conference committee still has not ratified the action. NASA has already determined that this use of *Titan III-C* would be technically feasible, but would require some modifications to the booster. Also, some changes would be needed in the *Surveyor* adapter.

. . . And Sees Little Use for Minuteman

A NASA study of an Air Force proposal that it use *Minuteman* missiles as space boosters has concluded that the idea is technically feasible, but there is little prospect that it will be adopted. Using *Minuteman* as a booster would require an added fourth stage, producing a payload capability a little greater than that of *Scout* and a little less than that of *Delta*. It is highly unlikely that there are enough payloads in that area to make the vehicle economically feasible.

INDUSTRY

New Apollo Suit Selection Forthcoming

NASA is expected to announce a decision within the next two weeks on Block II *Apollo* spacesuits. Contending are suits by Hamilton Standard, International Latex and David Clark. Block II flights will start as early as the *Saturn IB* flights in 1967.

Goodyear To Design Inflatable Spacecraft Skin

Manned Spacecraft Center has asked Goodyear Aerospace Corp. to demonstrate the feasibility of an inflatable enclosure that could be automatically deployed, pressurized and retracted around a rotating spacecraft in near-Earth orbit. The $59,310 study contract calls for design of a 16x32 ft. tough, flexible bubble with a 5-psi pressurized atmosphere. Within it, MSC planners say, astronauts could have additional protection during emergency spacecraft repairs in orbit and during crew transfer operations.

INTERNATIONAL

Cloudy Days at the Kremlin

Indicating that Soviet scientists can also operate in some confusion, a paper presented at a technical meeting in Paris identified an M/R associate editor as a scientist in the same field. Referring to an article written by Heather M. David, the paper said: "Heather (1961) carried out an experimental study on human beings in a pressure chamber with rarefactions corresponding to altitudes of 8,400 and 10,200 m . . ." The report, authored by a five-man group including A. G. Kuznetsov, went on to describe as "a similar" experiment one conducted by the Air Force's Dr. Billy Welch that was the subject of the original M/R article.

The Missile/Space Week

Mauler Program Killed

The Army on July 28 announced its decision to terminate development of the *Mauler* mobile air defense missile system.

Difficulties with mounting both a fire control radar and a guided missile launcher on the same tracked vehicle caused costly delays in the program, which began in 1960 and was to have resulted in a field-ready system by 1964 or 65. Some $200 million has been expended on the program.

Another reason for the cancellation may well have been recent improvements in the *Hawk* missile system. Also expected to help fill the tactical vacuum left by the cancellation are certain "new types" of defense systems for forward areas, such as combinations of automatic guns and the *Chaparral* (*Sidewinder* missiles mounted on a self-propelled vehicle).

Some *Mauler* components, such as the infrared acquisition unit, the acquisition radar and the fuse, show enough promise that they are being considered for continued development.

General Dynamics/Pomona has been *Mauler* prime contractor.

SRAM RFP's Due

The Air Force will make use of the new total package technique in procuring the *SRAM* missile system. It will be the first time the method has been applied to the purchase of a large missile system.

The service also announced last week that it was shooting for issuance of *SRAM* requests for proposals by the first of August.

Following the completion of the program definition phase by several companies, one contract will be awarded on a competitive basis for the development, production and lifetime support of the missile. The Air Force said the procurement planned for *SRAM* is similar to that for the C-5A aircraft.

Crucial Centaur Shot Due

A very important launch in the *Centaur* development program is scheduled as early as Aug. 4 from Cape Kennedy.

NASA's space science launch vehicle officials, already under heavy pressure to use the *Titan III-C* for many *Centaur* missions, may be forced to yield to the Air Force proposal if the upcoming *Atlas-Centaur 6* launch is not completely successful. Of the five previous *Centaur* flights, two were complete failures and none achieved a completely successful mission. In each of the three partially successful flights, minor technical malfunctions occurred to mar the liquid-hydrogen upper stage's performance.

AC-6 will be a full-scale simulated mission to determine *Centaur's* capability to inject a *Surveyor* spacecraft on a lunar-transfer trajectory. The vehicle will be flown along a simulated lunar-transfer trajectory. Full lunar-transfer energy for this mission is a velocity of about 23,000 mph at spacecraft separation.

Following separation from *Centaur*, the *Surveyor* model will continue on a highly elliptical Earth orbit with an apogee of about 515,000 mi. and a perigee of 100 mi. Orbital period will be approximately 32 days.

The launch will test several development features of the *Centaur* vehicle. These include a propellant utilization system, an uprated *Atlas* propulsion system, and a smaller volume liquid oxygen tank.

Centaur's guidance loop will be "closed" for the flight; guidance steering signals will be utilized for vehicle steering.

Shots of the Week

The Australian Weapons Research Establishment launched a *Skylark* sounding rocket carrying instruments for measuring ultraviolet emissions from celestial objects from the Woomera Range recently. The launch was sponsored by the Royal Society in England and carried a telescope specially designed by University College, London. The telescope was housed inside the rocket's nose cone. When the vehicle was clear of the atmosphere, the cone covers were jetissoned to allow measurements to be made through the telescope.

- The Air Force launched a *Titan II* ICBM from Vandenberg AFB, Calif., July 21. The firing was conducted by a four-man Strategic Air Command crew from Davis-Monthan AFB, Ariz.
- An Air Force F-4C fighter became the first victim of a surface-to-air missile in Viet-Nam July 24. Two of the Soviet-designed SA-2 missiles were fired at a formation of F-4C's; the second damaged three other aircraft. The aircraft loss prompted a U.S. attack on two of the North Vietnamese SAM sites July 27 that destroyed one site and damaged the other.

Mars Question Unresolved

NASA scientists report that *Mariner IV* photos are "inconclusive" in regard to the question of whether life exists on the planet Mars.

The scientists, at a press briefing held at the White House on July 29, said that the photos did not show anything that could be life, nor did they show anything that would preclude the possibility that life exists.

They declared, however, that they were not surprised by this because they never expected the photos to answer the age-old question.

Night Cloud Mapping Expected

Nimbus C, to be launched early next year, will provide routine nighttime cloud cover mapping with a four-micron infrared radiometer coupled to automatic picture transmission equipment.

Describing this as the most important step forward for this satellite, Dr. William Nordberg, NASA Goddard Space Flight Center told a session of the AIAA Second Annual Meeting in San Francisco last week that there is strong hope the radiometer could also be carried by a spinning *Tiros* operational satellite.

Initially the radiometer was thought suitable only for accurately stabilized Earth-pointing platforms, but results from the first *Nimbus* flight were so good that concentrated efforts are being made to convert the instrument into a fully operational weather tool for the *Tiros Operational System.*

Nordberg said that *Nimbus C* would also carry a five-channel radiometer with greatly improved calibration for measuring water vapor, stratospheric temperatures and radiation balance.

Nimbus B, to be launched in about two years, will give improved daytime cloud-cover mapping by use of an image dissector, electro-static tape camera. Nordberg said that this spacecraft will also relay surface pressure and wind information to a central data-processing center by interrogating surface stations located around the world. Other new instru-

ments to be carried are a five-channel ultraviolet photometer to evaluate solar influence on the atmosphere, and a 15-micron infrared spectrometer to measure "above clouds" temperature profiles.

Nimbus D, to be launched in about 4 years, will carry out "all weather" mapping by means of a 1 to 2-cm microwave radiometer. This will give ground mapping and measurement of precipitation in clouds. A 600-mc directional receiver will be used to record spherics distributions.

Hall on Manned Missions

Payloads costs, not booster capacities, will be the limiting factors relating to future manned missions in space, Dr. Albert Hall, deputy director for space in the Office of the Director of Defense Research and Engineering (DDR&E), told the Second AIAA Annual Meeting in San Francisco last week.

"Manned space flight undertakings will be expensive," Hall said. "The payloads that man will accompany into orbit *must* justify his presence in the man-machine loop in orbit if the manned system is to be cost-competitive."

In assessing military requirements in space in general, both manned and unmanned, Hall said, "Space is not a medium in which we can foresee an agressive threat. We do not believe that it makes military or economic sense for us, or our potential enemies, to place bombs in orbit, either as an overt threat or as a counter deterrent.

"From the standpoint of credibility, positive command and positive control, counter deterrents are much more effectively deployed on ground or sea."

Acknowledging that misuse of space might become a threat to the nation, Hall emphasized, "We could no more go unprotected against the misuse of space than we would dare go unarmed on land, sea or in the air.

"Consequently, we do have deployed anti-satellite systems. We will also continue research and development on such systems and techniques for inspection, so as not to be surprised and to insure that the objective of the United Nations Agreement on peaceful uses of space is honored."

DOD interest in space is centered principally in three areas, Hall said. These include: 1) exploitation of the space environment for specific military purposes (included here are such systems as communications, navigation, meteorology, and early warning); 2) performance of military tasks by man functioning in the man-machine loop in a satellite (*MOL* studies have examined gains and costs associated with use of man on space missions); and 3) close cooperation with NASA and other Government agencies in fields of space technology with strong potential defense relevancy. In the latter area, booster and re-entry technology, satellite stabilization, geodesy and materials research were mentioned.

Life Support System Delivered

An advanced life support system capable of supporting four men for 90 days in space has been shipped to Langley Research Center.

The system, developed by General Dynamics/Convair and demonstrated before acceptance, may be used some day in a manned orbiting space station. The huge steel system, 18 ft. in diameter and 18 ft. high, weighs approximately 60,000 lbs. It will be moved by ship through the Panama Canal to the NASA field center in Hampton, Va. It is too large to ship by rail or truck. NASA will use the system for advanced research in life support system technology.

An advance in the state of the art was demonstrated by the system when, for the first time using a completely integrated operational life support system, oxygen was regenerated from the carbon dioxide exhaled by the crew in the closed cabin environment. The reclaimed oxygen was returned to the cabin atmosphere for breathing.

The system—designed under the direction of R. C. Armstrong of Convair's life sciences section—also has the capabilities to provide control of temperature and humidity, permit handling of "space food" for the 90-day resupply period, and provide atmospheric contaminant control and provide personal hygiene facilities.

Subsystems required for the carbon dioxide conversion cycle include a molecular sieve unit which collects the carbon dioxide, a reduction unit which breaks down the carbon dioxide to water and carbon, and an electrolysis unit which converts water to hydrogen and oxygen. The oxygen is returned to the cabin for breathing.

Calculations for the water reclamation system were based on a requirement for approximately 11 lbs. of water for each of the four men in the crew for drinking, food reconstitution and personal hygiene. Approximately 16,000 lbs. of water would have to be carried aboard the spacecraft for a space flight of 1-year duration if facilities for reclaiming water were not provided.

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AIAA Meeting Reflects New Complexity

Sessions cover sophisticated new gyro developments, status of Titan III-C development, plans for multi-dish array, Earth survey

SAN FRANCISCO—A gyro with a drift rate of 0.01 arc second per year is being developed to study relativity. This and fluid rotor gyros highlighted a guidance and control session that characterized the growing sophistication of missile/space technology—surveyed here at the Second Annual Meeting and Technical Demonstration of the American Institute of Aeronautics and Astronautics.

The four-day meeting drew an estimated 4,000 aerospace scientists and engineers from the United States and abroad. Held in the city's impressive Civic Center, the 46 technical sessions heard more than 300 papers.

In addition, more than 200 lecture/demonstrations were presented by industry experts in the exhibit area. Attendees voiced particular praise for the expansive and informative exhibits produced by some 80 industrial and Government organizations.

● **The helicon gyro**—An intuitive feeling that the best accomplishments in unconventional gyros will come from quantum mechanics was expressed by Robert C. Langford, guidance and control director at NASA Electronics Research Center, in the opening paper of the heavily attended session on guidance and control.

Pointing out that this approach probably optimizes the search for microminiaturized "electromechanical" sensors, Langford listed a number of "very attractive ideas" being studied by North American Aviation's Autonetics Div.

The helicon gyro makes use of a circularly polarized electromagnetic wave that propagates with extremely low-phase velocity along magnetic field lines in a plasma. Helicon-wave frequencies of a fraction of cycle per second have been detected in a small sample of sodium. When a solid containing a plasma rotates, the frequency of the helicon wave changes, indicating rotation rate. Two helicon waves in two plasmas with opposite fields would provide an output indicating vehicle rotation directly. Lack of moving parts, simple construction and small volume are features of the device that suggest it will have utility as a high-g and rate device, said Langford.

Autonetics has also demonstrated a principle that may lead to a diode laser accelerometer. Tuning the lasing frequency of gallium arsenide diodes by hydrostatic pressure indicated that the stress response is enough to yield a very sensitive device with a wide dynamic range. An accelerometer is produced by supporting a proof mass between two lasing diodes. The two laser outputs are heterodyned to produce a beat frequency proportional to acceleration.

● **Alternative methods**—Other approaches to measure acceleration stress include thin-film techniques. High resolution is expected with use of radiofrequency ferromagnetic resonance in uniaxial magnetic thin films, taking advantage of the high stress sensitivity of FMR to the angle between an applied field and the anisotropy self-field in the film. The high angular sensitivity enhances the Q of the FMR (already high) by several orders of magnitude.

Magnetoacoustic effects can be used with FMR. In this case the strong effect of a stress field on magnetoacoustic resonance is communicated to the magnetic system through electron spin-phonon interaction. Stress can then be measured accurately by its effect on the FMR frequency. Sample size is about 0.00001 cu. in.

Current oscillation in a semiconductor plasma also offers the possibility of measuring acceleration stress. Oscillation frequency, existing after a threshold value of electric field has been applied across the sample, depends on sample dimensions (typically it is a cube 0.01 cm on a side) and material properties. Both of these are expected to be sensitive to stress.

Surveying the status of other forms of non-conventional gyros, Langford noted that ring laser gyros have improved in performance by a factor of 30 over the past year and have been reduced in enclosed area by about a factor of 8. Major randomness has been due to laser mode changes, and has been of the order of 5 to 10 degrees per hour. By reducing mode changing, workers at Sperry have cut randomness in the output to an equivalent rate of about one degree per hour.

● **Low drift goal**—A gyro with a drift rate of 0.01 arc second per year is

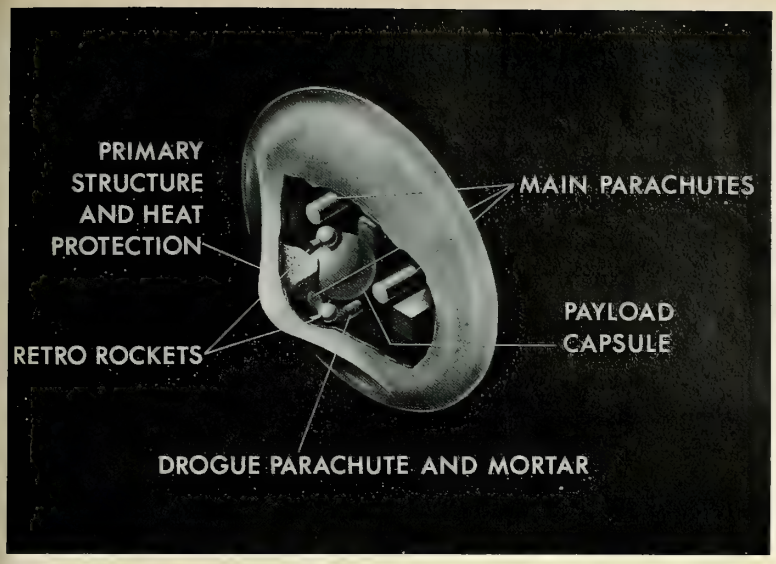
Manned, Unmanned Costs Compared

COSTS OF manned space missions versus payload savings and advantages of unmanned efforts were reviewed for the Management Session of the Second AIAA Annual Meeting in San Francisco last week by Dr. Albert C. Hall, deputy director (Space) of DOD's Directorate of Defense Research and Engineering.

Citing manned space launch costs, Hall estimated the funds required for delivering a multi-manned satellite into typical low-Earth orbit. The launch vehicle would cost $15-20 million, he said. The return vehicle cost would be $5-10 million and its support while in orbit another $10 million. Recovery force operations would add an additional $5-10 million—for a total mission cost of $45-70 million.

"On the other hand, if the same mission could be achieved by automatic equipment programmed from the ground, one could afford to raise the equipment weight from 5,000-10,000 lbs. to 25,000 lbs. and increase payload investment from $5 million to $10 million without exceeding the investment devoted to the manned system," Hall said. On the other hand, on-orbit equipments weighing 25,000 lbs., even with redundancy, may require man-servicing to keep them operating. It seems clear then that manned space systems must involve complex functions with intimate relations provided between man and the equipment to prove effective."

Citing the launching of *Titan II-Gemini* as an example, Hall noted the number of people required to adequately support manned flight. More than 100 mission support personnel were required, exclusive of those at Cape Kennedy. Almost 350 were involved at the Cape and the launch crew itself numbers 165 people. "Total highly educated and highly skilled people involved in one *Gemini* launch operation to support two astronauts is over 600," Hall said.



"COOLIE HAT" vehicle proposed by General Electric Co.'s Re-entry Systems Dept. for soft-landing a scientific payload on Mercury. Presented by engineers during AIAA meeting, concept has extremely high atmospheric drag for its weight, thus compensating for Mercury's rare atmosphere (1,000 times thinner than Earth's).

the aim of a program at Stanford University to check aspects of the general theory of relativity. Hope for achieving this low drift is based on operation in an Earth satellite's zero-g environment. The satellite will track the spherical gyro rotor without touching it, eliminating the need for rotor support. The satellite will also shield the rotor from the environment, reducing drift-producing moments to 10^{10} of those experienced by Earth-based gyros.

Readout of the gyro spin vector may make use of the fact that magnetic flux in a superconductor is quantized. An attempt will be made to sense the London magnetic moment of a superconducting unmarked isoinertial spherical rotor, as this moment is aligned precisely with the spin axis. A superconducting readout circuit is planned to give an automatic digital readout in flux quanta corresponding to 0.001 arc seconds.

At the other end of the scale, work is continuing with refinement of fluid sphere gyros for low-cost tactical missile guidance applications. So far, tests with a Sperry unit have shown a random drift of 0.01 degrees per hour and an ability to withstand 35-g shock.

Tests on a gimballed cryogenic gyro have shown a constancy of drift at least as low as 0.005 degree per hour during several test runs on different rotors, said Langford, who was very optimistic about the future of this form of gyro in high-accuracy applications. This drift rate is close to the ultimate sensitivity predicted for another form of gyro, the nuclear magnetic resonance type. Analysis of the relaxation times and number of nuclei in a typical proton spin sample suggest an ultimate sensitivity of better than 0.001 degrees per hour. Several models of this type of gyro have been operated under laboratory conditions and efforts are now concentrating on developing practical instruments.

● **Titan III status**—Some 2,000 lbs. can be added to the *Titan III-C* payload without making any changes in the basic Air Force booster system.

Analysis by Martin-Denver experts of flight data from the vehicle's maiden launch on June 18 indicates that the payload limit can be raised from 25,000 to 27,000 lbs.—based on the propulsion performance of all four stages.

William G. Purdy, general manager-launch vehicles, told the booster status session at the AIAA meeting that continuing flight-testing will provide a basis for upward revision of payload weight guarantees for both the *Titan III-A* and *Titan III-C* configurations in all mission design categories.

MISSILES AND ROCKETS' *coverage of the San Francisco AIAA meeting was provided by Editor William J. Coughlin, West Coast bureau chief Willard E. Wilks, Senior Electronics Editor Charles D. LaFond, Propulsion/Materials Editor John F. Judge, Electronics Editor Rex Pay, and Contributing Editors David A. Anderton and Robert Lindsey.*

Performance of each of the four stages during the initial flight was better than nominal—resulting in orbital injection some 21 seconds earlier than planned.

Stage I outage was 1,104 lbs. of fuel, or 0.44% of usable propellant; Stage II outage was 104 lbs. of oxidizer, or 0.16%. About 4,119 lbs. of usable propellant margin existed at injection—822 lbs. more than expected.

Higher velocities than the nominal were attained in each stage's performance.

● **Changes at hand**—The analysis is being discussed with experts from Space Systems Div., Air Force Systems Command. Indications are that the revised payload ability will result in some changes to the currently planned payloads in the flight-test program.

The next *Titan III-C* is due for launch from the Cape Kennedy ITL complex on Sept. 23, but is likely to slip to Sept. 30. This vehicle will not be affected by the payload increase.

Purdy also detailed payload configuration studies. The Martin expert said the *Titan III-C* can handle a payload diameter of 262 in. Earlier studies had limited this diameter to about 156 in., but errors in both the computation and the wind tunnel data were subsequently discovered.

SSD has ordered additional wind tunnel tests to verify the 262-in.-dia. envelope. If this is confirmed and the extra ton of payload is fed into the *Titan III-C* program, some significant changes probably will be made in the long-range mission potential of the booster.

In any event, the additional payload parameters can do no harm to whatever specifications exist in the *Manned Orbiting Laboratory* (*MOL*) program. In fact, some industry spokesmen view the margin with some joy, since it might ease problems when the *MOL* hardware hits the shop floor.

● **120-in. progress**—Barnet R. Adelman, United Technology Center president, briefly reviewed the 120-in. solid rocket Stage Zero program.

He noted that the major problems anticipated in the development program turned out to be minor, but some unexpected headaches developed.

Largest single delay in the tightly scheduled solid-motor project came from problems in welding the Ladish D6 steel used in the motor case. The increased thicknesses used in the *Titan III-C* motor cases, as compared with those in the *Minuteman* D6 cases, proved to be the cause.

Adelman said the thrust vector control system carried itself, since some 30% of the side forces generated translated themselves to the normal form.

● **Titans for VAFB**—Brig. Gen. Joseph S. Bleymaier, SSD deputy com-

mander for manned systems, chaired the *Titan III* launch vehicle status report. He told the session that the present manufacturing base can turn out nine complete *Titan III-C* vehicles per month.

Since the ITL complex at Cape Kennedy can launch a maximum of six vehicles per month, three are left for any Vandenberg AFB operations on the West Coast.

Bleymaier indicated that at least three of the 12 remaining *Titan III-C* vehicles are open for Vandenberg launch, should such a decision be made.

He said a slight revision in ground equipment at Cape Kennedy would make it possible to hold the huge vehicle at the T-minus-60-seconds condition for a full month.

The *Titan III-C* actually is in its production phase now, and Bleymaier said the production does not differ essentially from the manufacture of the 12 initial test-flight vehicles.

● **UTC getting follow-on**—In a surprise move, Bleymaier confirmed that United Technology Center would get the first follow-on production contract for the 120-in. solids.

The SSD expert told a press conference that the initial idea behind the *Titan III* building-block booster effort was to avoid paying for the establishment of industrial facilities.

UTC built its processing complex and staffed the development program with some $40 million of United Aircraft Corp. corporate funds. The highly profitable production follow-ons will help to amortize this investment.

The announcement was greeted with mixed feelings by industry propulsion sources. Some believe it will effectively eliminate UTC from serious consideration in any 156-in. program buildup. UTC, of course, thinks differently.

● **Booster planning pains**—Bleymaier broke all AIAA records in hustling his four speakers through their presentations so that Dr. Alexander Flax, Assistant Secretary of the Air Force (R&D), could review the factors affecting planning and development of large launch vehicles.

Flax described the difficulties in anticipating advanced payload requirements. He also pointed out that payload costs are an individual thing and could easily represent the major expenditure in a launch using a well-developed booster with a long and useful lifetime.

Payload variations in weight and configuration pose another problem in costing booster operations. The high cost of payloads is due in part to weight limitations, and large boosters could alleviate this factor.

In addition, the cost of a given launch can rise if the blast-off is delayed. Thus the intelligent development of boosters must consider reaction times.

The current building-block approach to boosters—apparent in both the *Titan III* and the *Saturn* families—precludes the optimization of specific launchers to specific missions. There have to be general compromises.

Flax noted that the enormous expense of developing large boosters forces selective planning. He said the dollars necessary to the orbiting of 20,000 lbs. could operate a squadron of B-52 aircraft for a full year.

Flax also indicated the direction of *Titan III-C* growth would be through 156-in. solids. He tied this with the work now being pressed in high-pressure liquid engines by both NASA and the Air Force. These could be used in upper stages or in the development of aerodynamically recoverable boosters.

He said the Air Force is geared to identify concepts in recoverable boosters which may drastically alter earlier studies. Air breathers are a case in point.

● **Multi-dish array**—Imaging of the radio sky at the hydrogen line with a resolution comparable to that of a one-inch optical telescope could be achieved by using an array of 10,000 steerable dish antennas, said Bernard M. Oliver, vice president of Hewlett-Packard Corp., speaking at an AIAA luncheon. Urging the need for a $2-billion program to develop such an antenna, Oliver pointed out that it would indicate the frequency at which life occurs at our stage of evolution.

Each dish would be about 200 ft. in diameter, alt-azimuth-mounted, computer-controlled and synchronized with all the others. Accurately phased amplifiers would convey the dish outputs to a combination acoustic-optical image synthesizer, which would convert the antenna's field of view at radio frequencies into an optical image comparable in resolution to a television picture.

Sensitivity of the system would be such as to reach back to the origin of the universe, if this event was copiously signalled at radio frequencies. It should also be able to pick up evidence of television broadcasting services used by civilizations at distances of up to 100-200 light years.

● **Earth survey**—With the future establishment of a firm manned orbital space station program, the initial data base for an Earth survey effort could be obtained within 4 to 4½ years and 10 to 12 years would be needed to obtain sufficient data to support an operational program, according to an IBM official.

Sidney Shapiro, technical director of the orbital research laboratory experiment integration study contract being performed for NASA headquarters by the firm's Federal Systems Div., discussed the program's current status at one of the lecture-demonstrations in the exhibit area.

Pointing out that NASA's near-Earth space effort is now entering the exploitation phase, Shapiro described the advantages and early uses of a manned lab in a 200-mi. orbit. The latter included oceanographic-buoy readout, iceberg detection and tracking, meteorological and astronomical studies, and forest fire detection and location. Particular emphasis was made by Shapiro on the agricultural uses of such a satellite.

A single vehicle in a polar orbit or one launched at a 65-degree inclination would be sufficient, he said.

Anticipating an overpopulated, underfed Earth community in the not-too-distant future, Shapiro suggested that a survey vehicle could be employed to inspect forests and crops to detect disease, study soil conditions and moisture content and possibly provide data to help predict yield data.

Such a vehicle using optical, infrared, ultraviolet and radar sensors could provide rapid Earth coverage with a large over-view and a full spectral range.

However, Shapiro pointed out, multi-spectra, wideband equipment must be developed and a broad research effort will be needed to obtain, define, and catalog reflectivity signatures and imagery reference data.

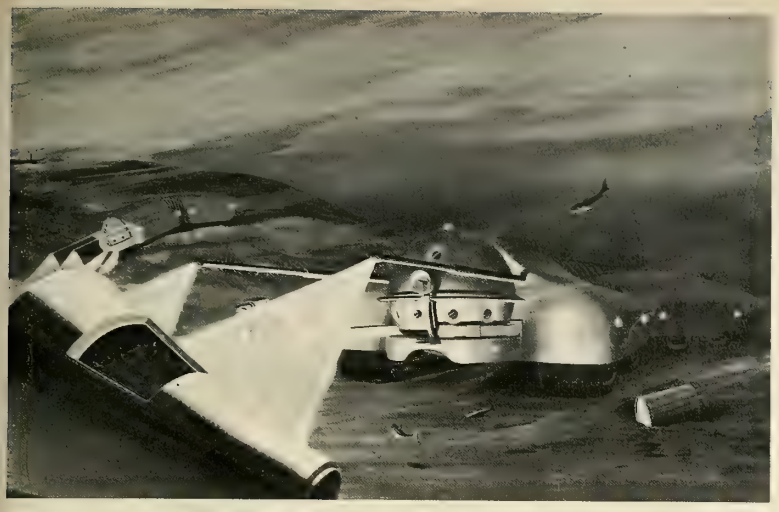
Man, said the IBM expert, could greatly enhance a survey vehicle through his ability to selectively limit observations and provide a useful but compressed output.

IBM's nearly $1-million contract, begun in mid-1964, will be completed this fall. The effort is aimed primarily toward determination of experiments leading to practical exploitation of near-Earth space. Also, the firm will propose needed instrumentation, outline a research effort to support an experimental vehicle and to point out long-lead-time items requiring early development.

● **Equipment needs**—Although specific sensors and on-board laboratory equipment will not be detailed in the firm's report, Shapiro did suggest to M/R the kinds of devices that might be required. These include optical instruments ranging from spotting telescopes to units of up to 60-in.-dia. and low-light-level TV. IR sensors would have to be versatile in frequency coverage and provide simultaneous multiband detection. Radar at X-band and higher would be useful, he said, as would coherent side-looking radar capable of high resolution.

On-board data processing electronics for a vehicle such as *MORL* would need up to a 32,000-word memory and be capable of 250,000 operations per second.

Man would essentially simplify instrumentation and operation, Shapiro stressed. His ability to select the best



UNDERSEA VEHICLES powered by nuclear radioisotope fuel capsule are envisioned in concept advanced by Aerojet-General in technical paper at AIAA meeting. As indicated in artist's drawing, they might be used for military reconnaissance or assaults or commercial work. Here crawlers salvage a Mercury spacecraft.

sensor for a given target at the right time could significantly minimize data reduction time. Man also could make adjustments, change film and antennas and perform the multitude of other manual tasks needed in carrying out different experiments over a long time period.

● **Plasma shield research**—By charging a spacecraft with a positive-potential electrostatic charge, future astronauts may be protected from the hazards of solar radiated protons. In his paper on "Plasma Radiation Shield," Dr. Richard Levy of the Avco-Everett Research Laboratory described a plan of this kind now being studied under his direction for the Air Force and NASA.

By controlling an electron cloud with a magnetic field, Levy said, a potential can be maintained about a space vehicle of sufficient strength to repel high-velocity, positively-charged protons emanating from the Sun.

A result of solar storms, such proton showers travel at a speed of roughly 62,000 miles per second, the Avco scientist declared. The use of specially-built shelters within a spacecraft or the use of high-strength magnetic fields have been proposed as methods for affording protection, Levy pointed out; but he said the Avco approach would require only a moderate-intensity magnetic field and the device would be only 0.05 the weight.

Levy suggested that employing a doughnut-shaped spacecraft design equipped with a super-conducting magnet might generate a field whenever necessary that would loop through the center hole and around the vehicle shell. Negative electrons directed from the craft into the field would become entrapped, creating an electron cloud, Levy claimed. The cloud would envelop the craft as an outer doughnut shell.

With a spacecraft voltage of 200 Mev, said Levy, the kinetic energy of the incoming protons would not be sufficient to pass through the protective shell in any significant quantity.

At present, the Avco study is concentrating on learning to achieve a stable electron cloud—a factor critical to success of the protective shield. Electron containment and low-voltage (10,000 volts) injection experiments have been successful to date, Levy asserted, and results have agreed with theoretical predictions. He emphasized that at present there is no apparent reason to expect that the required higher voltage levels cannot be achieved.

● **Satcom & aircraft**—"We think the synchronous satellite will provide the communications necessary for the Supersonic Transport," Pan American project electronics engineer W. A. Downie told a communications Satellite session. With 300 planes expected to be in the air over the North Atlantic at any given time in the 1970 period, improved aircraft communications will be essential, he said.

Comsat Corp.'s manager of engineering told the session that to provide this communications boost by means of a synchronous satellite would call for 1-3 kw ERP from the satellite. Aircraft would need to carry 250-500 watt transmitters and phase-lock, low-noise receivers.

Alternative approaches in which aircraft would use their normal communications equipment are being studied. These involve floating platforms tied together either by communications satellite or by cable (a British proposal). The aircraft would then be in communication with the platforms.

● **Comsat choice pending**—Dr. Sidney Metzger, manager of Comsat Corp.'s Engineering Div., disclosed that the group still hopes to put out RFP's to the industry for the advanced communications satellite having approximately 1,000 voice channels. A decision has not yet been reached on whether a synchronous or medium-altitude satellite will be required, he said.

Tests are scheduled to find out subscribers' reactions to the delay experienced over synchronous satellite voice channels. "We feel that a realistic answer should be obtained by calling back several thousand subscribers during the coming months," he said. Data on their responses should be available by the end of the year.

Tests with *Early Bird* have shown that it does have the capability of carrying 300 telephone channels and still meeting noise-level requirements. In the next two weeks tests will be made with Europe to confirm that 60 duplex voice channels and a one-way television program can be carried together.

A technique has been worked out for operators at antenna terminal stations to talk to each other directly via the satellite without limiting the communications capability of the *Early Bird*. Operators have two voice and two teletype channels available for simultaneous use.

Comsat Corp. expects to come up within the next couple of months with more definite answers on the economics of network television relays from a synchronous satellite, said Metzger.

There are no technical problems in building a satellite capable of carrying nine television carriers simultaneously—the number required for three networks broadcasting to three time zones. He estimated that an *Atlas-Agena* could orbit a 750-lb. satellite with an effective radiated power of 1,000 watts. Development of such a power would be accomplished by using 10-16 5-watt TWT's. The satellite's power would call for a medium-size receiving dish installed at local television stations.

● **"Burly Bird"**—Hughes Aircraft Co.'s proposal for the next communications satellite, *P 304*, sometimes called *"Burly Bird"*, was described by Boris T. Subbotin to the session. This is designed for an initial launch no later than 1967 and has a channel capacity in excess of 600 channels. Lifetime is set at five years with a potential for ten years built into the design. Either single launch (improved *Delta*) or multiple launch techniques (*Atlas-Agena*) can be used, and the satellite has synchronous or medium-altitude options. ■

No Technical Bars to Deploying Nike-X

Problems now concern proper mix of system, construction of shelters and international political effects; odds for deployment have gained

by Donald L. Zylstra

REMAINING PROBLEMS related to development of the *Sprint* missile and an improved *Zeus* vehicle as components of the *Nike-X* anti-missile system are now "of an engineering nature" and won't be obstacles in any Dept. of Defense decision to deploy it. Technical experts are agreed that concepts essential to operation of all components of the *Nike-X* system are now sufficiently proven to warrant its deployment.

More important hurdles still to be passed in any deployment decision include: a settlement as to configuration of the initially deployed system—whether this will feature *Zeus* interceptor missiles primarily—and to what extent the faster-acceleration, shorter-range *Sprint* will be a part of deployment; placing of the need for civilian fallout shelters in its correct perspective as a concomitant of any *Nike-X* deployment; assessing the unsettling effect *Nike-X* deployment might have in terms of Soviet decisions to increase their ICBM efforts.

In addition to these considerations, Secretary of Defense Robert S. McNamara and his associates must come up with the most accurate estimate possible about how the world will look in 1970—in terms of the number of nuclear-capable nations and their potential for inflicting damage on the United States. Proliferation of this nuclear capability can have wide implications in terms of the kind of anti-missile system the U.S. should employ.

Another factor that will profoundly affect Pentagon calculations will be the ultimate estimates about how effective *Nike-X* will be in limiting damage to U.S. real estate and manufacturing facilities, as well as in preserving lives in the event of an attack.

● **On upswing**—Hopes for deployment of *Nike-X* have followed a roller-coaster pattern during the last three or more budget years. Optimism among the system's proponents is now nearing the top of its greatest rise to date. The budget-making cycle requires the go or no-go decision for FY 1967 during the period between the first of October and late December this year.

Estimates that *Nike-X* will gain deployment authorization, with tooling and production funding included in FY 1967 military budget requests, vary. But the odds offered are much more optimistic than at any time in the last three fiscal years. Most optimistic predictions have been 6 to 4 in favor of authorization of some form of deployment late this year.

While even the most austere deployment option would cost from $5 billion to $8 billion, with expenditures spread over a minimum of four years, maximum first-year funding request for early tooling and deployment preparations is estimated at $200 million or less. (Such added funding would be over and above annual increments to complete development and testing of the system.) In subsequent fiscal years, this deployment funding rate would be drastically increased as the deployment program gained momentum.

● **Sprint full partner**—Although the improved *Zeus* anti-missile missile may predominate in numbers in any early *Nike-X* operational system, at least some *Sprint* capability would be present from the outset in any deployment. The improved *Zeus* missile is strictly what its name implies—the result of a move to keep its continuing development in step with advances in the state of the art. Tendencies to emphasize increases in range have been characterized as misleading, since time to intercept outside the sensible atmosphere is the critical factor. Presumably the main improvement in *Zeus* design has been in this area.

This added performance, coupled with additional sensitivity and flexibility on the part of the MSR radar which controls the *Zeus* flight, constitutes the largest factor in the second major improvement in *Zeus* since initial design characteristics were laid down in the late 1950's.

● **MAR & MSR**—Technological progress in the *Nike-X* program has proven particularly encouraging in several instances. Changeover from a mechanically directed to a phased-array radar concept and improved plans for netting or locating both MAR and MSR components have gone far to solve problems associated with fireball blackout from detonations of either intercept warheads or the incoming enemy missile.

The extent of this blackout phenomenon is related to the altitude at which the intercept and accompanying detonations occur.

Rapid scan and directional change features of the phased-array radar, abetted by their careful placement in proposed *Nike-X* deployments, would reduce the "barrier" effect of fireball blackout. Now such a phenomenon can be regarded as essentially a temporary "blind spot," with carefully netted, overlapping MAR and MSR coverage seeing and controlling intercepts around, behind and in front of the affected area in the atmosphere or in space.

Because of its operation in the sensible atmosphere, probably at altitudes in the 20-30 mi. range, there is a definite premium in limiting the size within reason. Such *Zeus* increases would be desirable insofar as they involve no penalties in cost, missile acceleration or other performance.

● **How to kill**—The most closely classified aspect of the operation of the *Nike-X* system is the exact manner in which the kill or disabling of incoming hostile missiles is accomplished. Defense sources are exceptionally close-mouthed about whether heat, or various other radiations, or electromagnetic effects are the destructive factors.

Effectiveness of all these items vary with altitude and with warhead design. For instance, the X-rays generated by a nuclear detonation in space as a major part of a warhead's radiation yield would have very different effects than in the atmosphere, where they contribute significantly to the blast effects produced. Thus, detailed information about such aspects of the system would aid a potential enemy in designing evasive techniques or countermeasures.

In theoretical war-gaming of the *Nike-X* system to assess its capability, designers and tacticians deliberately assume that all incoming missiles are "salvage-fuzed." This expression means simply that any enemy missile is presumed to have sensor equipment designed to signal detonation the instant it detects any attempt to intercept or impede its progress.

Such built-in reaction might afford an opportunity for inflicting at least partial destruction on the intended target. Or, failing that, the missile detonation could at least complicate the intercept task for the defender by introducing blackout phenomena and other side effects.

The very statement that developers

assume "salvage fuzing" as the extreme or ultimate case would indicate that intercept and kill techniques employed by the *Nike-X* system anticipate many instances where enemy ICBM's could be intercepted and incapacitated without detonating.

● **Chinese threat**—Strategy and tactics as dictated by deployment of *Nike-X* see a potential enemy targeting on the basis of intelligence information which gives him "defense-no defense" data. In contrast with the assumptions basic to defense of cities or other targets against a saturation ICBM attack with the sophisticated warheads and decoys the Soviets can deploy, a primitive threat mounted by Red China might be a very different matter.

Thinly deployed launch sites, equipped predominantly with *Zeus* missiles, could prove very effective in protecting large areas against the small supply of unsophisticated missiles with which Red China might first pose its nuclear threat. Such weapons might be numerically limited to a few dozens and would probably lack sophisticated decoys or penetration aids.

If the earlier concept of protecting only highly populated industrial areas and cities against saturation attack were followed, a nation like Red China could capitalize on this posture by scoring critical damage to a variety of unprotected, less populous targets—particularly if it were content to take advantage of the terror factor generated by an attack solely against civilian populations.

● **Shelter dilemma**—With the development of nuclear devices by Red China now a reality, the DOD attitude toward building civilian fallout shelters as an essential concomitant has undergone considerable change. Whereas a full-scale shelter effort was deemed a vital requirement to accompany deployment of *Nike-X* in defense of the nation's concentrated population and industrial complexes, an all-out shelter program isn't considered as high priority a requirement in a deployment of a limited configurtion of the system against what the Pentagon labels an "nth" country, primitive threat by a nation such as Red China.

Should deployment authorization take the form of a system designed to meet this primitive threat, Secretary McNamara might drastically scale down the shelter requirement from the $5 billion estimated as essential to accompany an optimum *Nike-X* deployment costing $20 billion to $30 billion.

● **SAM-D**—Any decision to deploy an anti-missile system must take into account the necessity to protect the *Nike-X* launch sites themselves. While the system would be its own protection against ballistic missiles, consideration would have to be given to the threat from air-breather or aerodynamic devices launched against *Nike-X* sites through the lower atmosphere with relative immunity to radar detection. In recognition of this need, the Army has established its *SAM-D* missile program.

In testimony earlier this year before Congress, Secretary McNamara estimated that such a protection system might cost $1.5 billion for a limited *Nike-X* deployment costing $8.5 billion and as much as $3 billion for a deployed system costing $17.5 billion.

In reviewing the necessity for protecting both ICBM and AICBM launch sites against enemy nuclear attack, the Pentagon has even considered the possibility of adopting the *Minuteman* missile with an upper stage configured for an anti-missile role—presumably equipped for intercepts at much greater ranges than those contemplated for *Zeus*. Both missiles and silos might be altered in an ultimate projection of such a concept, so that "every other silo defends the one next to it."

Four years is the minimum estimated period for development of an operational *Nike-X* system from the time deployment authorization is granted. To accomplish this goal, designers and developers at all industry and military levels seem agreed that optimum concurrency is essential—in finishing development and testing, in building the operational system and completing site installations. Any other course might see the nation achieving too little too late—with the added risk of deploying an obsolescent system.

Another factor which might influence the deployment decision is the possibility that an anti-nuclear-proliferation treaty could be negotiated. Currently the USSR is on record with the view that "ballistic missile defense is not negotiable." Whatever the eventual U.S. position on agreements to freeze production of offensive or defensive systems, most observers are confident the nation will never accede to any agreement freezing research and development in these areas.

● **Flexible radar**—Development people in both the industry and military camps emphasize the flexibility of the *Nike-X* system's phased-array radars. This feature is a leading factor in the ability of a limited initial deployment of the system to grow by accretion, without the need for discarding any original equipment when new components are added. The essentially modular nature of both the MAR and MSR radars lends itself to an austere initial installation. Later additions of additional units to the radar arrays and addition of more computer capacity is entirely feasible with this design.

In an austere deployment, with a preponderance of *Zeus* missiles and few *Sprint* vehicles, the number of MAR long-range acquisition, identification and tracking radars might be kept to the barest minimum. Such a procedure is possible because the MSR is flexible enough to assume these MAR tasks on a lower-powered performance level and at the same time perform its primary function of directing the intercept missiles to their targets. With later additions of more *Sprint* and *Zeus* missile, the higher-power MAR units could be added and the performance of all earlier radar installations materially improved.

All computer equipment associated with the *Nike-X* system is designed with repetitive basic modules, interchangeable between MAR and MSR installations. Their capacity and performance in an optimum MAR unit has been described as "like having dozens of IBM 7094 computers in every MAR."

The first MAR radar is in operation at White Sands Missile Range, N.M. *Sprint* propulsion vehicle tests are also underway there, and pop-up tests with a dummy vehicle have proved the validity of that concept. First *Sprint* test to feature the full flight sequence, including the gas-ejection pop-up phase, will be third in this development series. This third test firing is dependent on the completion of test silo facilties at White Sands late this summer and is scheduled tentatively for early fall.

Tactical prototype MAR and MSR radars are being built at Army's Kwajalein Island complex in the Pacific. The former is under construction on Kwajalein itself and the latter (MSR) will be built on nearby Meck Island.

● **Delusion of defense**—With all of the agonizing appraisals now in progress relative to the *Nike-X* deployment decision within the Defense Department, a series of surveys of the American public indicates that the average man in the street is convinced his country already has an effective anti-missile defense. Two-thirds of the citizenry currently labor under this delusion.

Such reactions are indicative of basic faults in a DOD policy of super-secrecy in the matter of its missile activities and posture—a situation vigorously decried by Congressional committees and other public sources which have branded it as lamentably unrealistic.

Presumably if the American people are to go undefended against a growing missile threat, they should not be lulled into this false impression of security. Also being questioned is the right of DOD chiefs to make this milestone decision in an undercover atmosphere without public scrutiny of the factors involved in the decision—particularly, as some critics note, when the basic technology for anti-missile protection now appears to be well in hand. ■

Space Agency To Have New Office

Mission will be to oversee development of Apollo Extension Systems, Saturn IB/Centaur, with subdivision for each system

by Hal Taylor

NASA WILL ESTABLISH a new *Apollo/Saturn* applications office in the near future. It will direct development of the *Apollo Extension Systems* and the *Saturn IB/Centaur* launch vehicle.

The new office will be headed by John Disher, currently test director in the *Apollo* program office. He will report directly to Dr. George E. Mueller, associate administrator for manned space flight.

MISSILES AND ROCKETS has also learned that Disher's office will have two subdivisions—the *Saturn IB/Centaur* office directed by Col. Harold G. Russel and the *Apollo Extension Systems (AES)* office directed by William B. Taylor. Both will report directly to Disher.

The establishment of the new office will mark a major milestone in getting both the three-stage launch vehicle and the *AES* spacecraft projects off the ground.

A request for proposals from industry on program definition of the payload integration for *AES* is expected from the Manned Spacecraft Center in the near future. MSC will have field center responsibility for the *AES* spacecraft as well as for the Earth orbital and probably lunar orbital missions. Although none has been established as yet, it is certain that an *AES* program office will be added to the MSC organizational structure in the next month or so.

A *Saturn IB/Centaur* office has already been established at the Marshall Space Flight Center, which has field center responsibility for development of that launch vehicle.

Stanley Reinartz, formerly deputy manager of the *Saturn I* and *Saturn IB* program offices, has been named to head the three-stage launch vehicle program office.

● **New primes seen**—Reinartz told M/R that he is currently engaged in defining the scope of the *Saturn IB/Centaur* mission. He said it appears that the Chrysler Corp.—prime contractor for the *Saturn IB* first stage—will be involved in some systems engineering work. He said that at the present time "there are no plans for prime *Saturn IB/Centaur* contracts." This will probably change, however, when hardware development funds are requested in the space agency's Fiscal Year 1967 budget.

Marshall will also be responsible for lunar surface *AES* operations, and it is also expected to establish a program office in the near future. (M/R, June 7, p. 17; June 21, p. 14).

As the agency moved to complete its in-house management team, a meeting of NASA and other scientists was held at Falmouth, Mass. to further define experimental payloads for Project *Apollo* and *AES* missions.

Willis B. Foster, director of NASA's Office of Manned Space Sciences, served as chairman for the two-week meeting.

● **Timetable**—Project definition and hardware funding of some of the early Earth-orbital flights is slated to begin with FY '66 funds. Substantial development funds will not be available until FY '67.

The first *AES* flight could begin in 1968. It would be a 14-day orbital mission that would use basic *Apollo* hardware with no modifications. Block II Command and Service Module fabrication for these flights will begin later this year, according to the current schedule.

The flights will be scheduled on the basis of the availablity of *Saturn IB* and *Saturn V* boosters, but they will continue through 1969 and early 1970.

The second group of flights will begin in 1970 and continue in 1971 at a rate of five or six per year. These will be extended orbital missions of up to 45 days. The Command and Service Modules will be modified so that additional life-support and power systems can be carried. Lunar surface missions of up to 14 days will also be made during this period.

Regarding *Apollo* and *AES* scientific experiments, Foster said those for the Earth-orbital phase are best defined thus far, since they are more near-term and involve no launch window type of planning input. Those *AES* experiments to be launched by *Saturn IB* upon which most activity is now centered include remote sensing experiments involving observation by cameras, UV and IR sensors, radar and visual. These will be related to work in geology, meteorology, oceanography (sea-state), agriculture, forestry and solar and stellar astronomy.

● **Brainstorming**—The two-week session at Falmouth culminates a six-week series of meetings on Cape Cod, all of which had a bearing on the *AES* program. Before the Falmouth meeting, the National Academy of Sciences completed a four-week summer study at Woods Hole in which the role of man in future astronomical, planetary science, biological, medical and physiological programs—including space-based projects—was discussed.

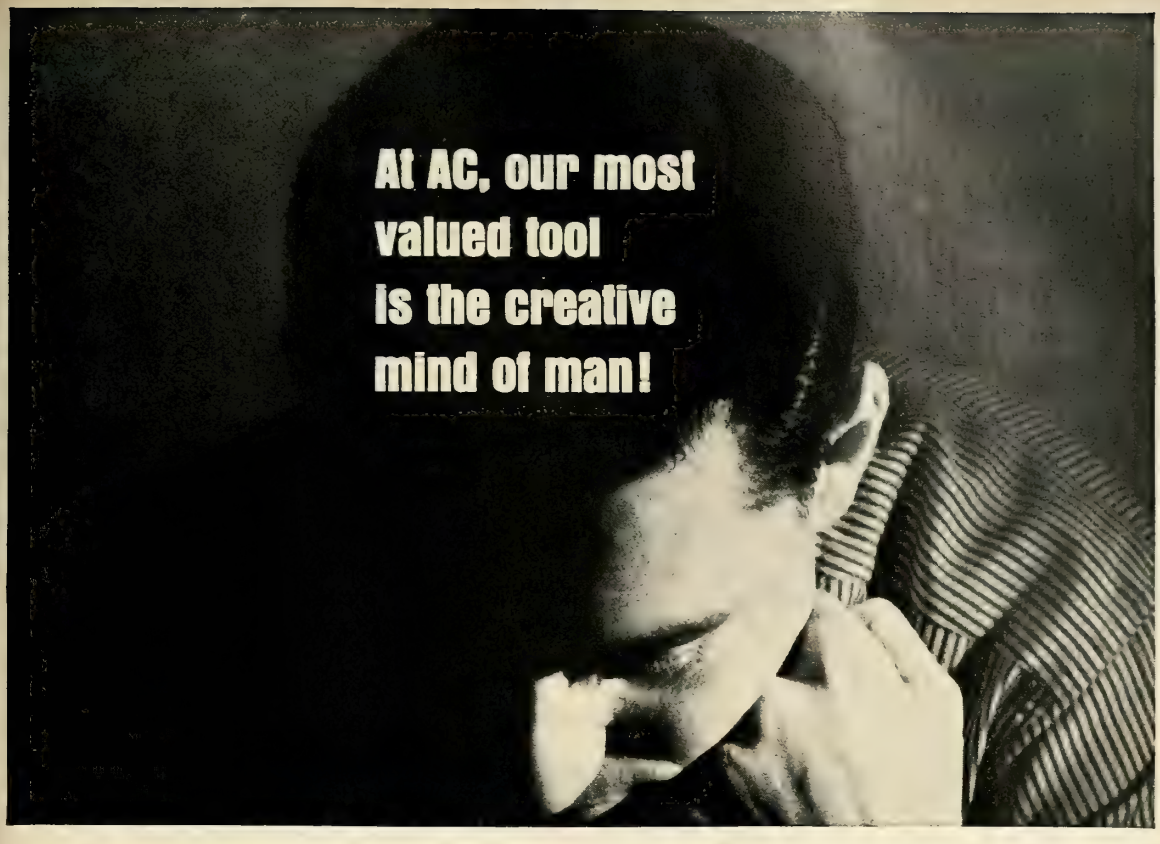
A planetology subcommittee of NASA also met at Woods Hole, including scientists from outside NASA, to help determine the role of *Apollo* and *AES* in this area. Following this was the two-week meeting at Falmouth, which was essentially aimed at converting some of the broad advice into fairly definitive program packages, according to Foster.

The first week of the Falmouth meeting also dealt with the Lunar Surface Experiment (LSE) package for *Apollo*. Foster called this "a crash program on which NASA will have to move quickly." He said three Phase I contractors will be selected and funded in August for six-month design studies. Phase II will have a single contractor, probably to supply hardware for the first three *Apollo* flights. A similar but larger package will be part of *AES*.

Foster said NASA is having difficulty finding university scientists who are able to propose experiments with the very long lead times involved in *AES*, particularly the lunar portions.

He said NASA believes the right place to do research is in the universities. He also expressed the opinion that the large size of experiment payloads, for example those on the order of 3,200 lbs., was another design factor that had to be impressed upon scientists accustomed to thinking of much smaller items.

Foster listed improvements needed in on-board power and data processing equipment as far as it affected data handling, storage and transmission. He also said there still had been no decision on the best way to perform true zero-g experiments aboard an *AES* spacecraft. In the large telescope experiments, he said a major problem remaining was the requirement to remove the man from any effect upon scope stabilization. He said experiments to aid in solving this problem would begin in the *Saturn IB*-boosted *AES* series. ■



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Systems Engineers
Will perform error analysis and analog/digital simulation of guidance control loop and vehicle flight dynamics. Degree required plus experience in systems design and background in automatic control theory.

Semiconductor Circuit Designers
Positions involve development of servo amplifiers, A.C. static inverters, pulse circuits and D.C. motor controls. Degree required, plus design experience.

in Los Angeles:

Sr. Research Engineer
Responsibilities will include the study and development of miniaturized DRO and NDRO memory systems for airborne computers. This individual must have five or more years experience in the field of digital circuits and magnetics. BS in EE or Physics required, advanced degree desired.

Sr. Scientific Programmers
Responsibilities include the development of large scale digital computer programs for orbit determination and simulation of highly complex space and missile guidance systems. BS or BA Math or Physics plus experience on IBM 7000 series required.

Software Development Engineers
Responsibilities include the development of computer programs used for the design of airborne computers. All phases of computer design are involved. BS in Math or Engineering required plus experience in digital computer programming and/or logic design.

Digital Systems Engineer
Responsibilities include the reduction of system requirements into computer specifications; numeric and error analysis; and preliminary computer design. Requires 6 or more years of directly applicable digital experience. Advanced degree in EE, Math, or Physics desired.

in Boston:

Programmer (Scientific/Real Time)
Analyze and develop digital computer programs for solution of engineering problems related to inertial navigation systems and components. BS in Math, Physics or EE required with experience in machine language and Fortran.

Senior Physicist or Engineer
The particular area of investigation relates the application of mechanics, electricity, nucleonics and physical phenomena to inertial measurement components such as gyros and accelerometers. MS or PhD required plus experience in the theoretical and experimental development of conventional and unconventional sensing devices.

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Mr. R. B. Schroeder, Dir. of Scientific and Professional Employment, Dept. 5753, AC Electronics Division, Milwaukee, Wisconsin 53201. Your resumé for one of the above positions will be reviewed in confidence and a reply made to you within a matter of days.

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PROPULSION

Inertia Prevents Big Solids Exploitation

The campaign by proponents of big solids in both the Air Force and industry is foundering on the immense U.S. investment in liquid rocket technology. The proponents of solids have been pushing for the development of a family of missiles and space launchers based on a set of 156-in.-dia. building blocks—which, at the moment, consist of plastic models. The *Titan III-C* is believed to have proved the case for large solids with its successful maiden flight. Various cost analyses have detailed the advantages of solids in this respect. "There's nothing wrong with the saleability of our product," a spokesman says, "the liquid interests just have too much to lose." This is especially true from an employment standpoint—the same people cannot work on both. In spite of the impressive record of solids on all fronts, big solids supporters say the idea is simply not being bought because of vested liquid interests in industry, NASA and even in the Air Force. Ballistics Systems Div. remains to be convinced. In fact, informed sources close to the ICBM program say that as far as BSD can estimate at the moment, a replacement for *Minuteman* might be a liquid rocket using advanced fuels.

Gun-Launched Rockets Successful

Two 8-in.-dia. Martlet 3-B motors, each containing 120 lbs. of high-energy, rubber-based solid fuel survived launching from a modified 16-in. naval gun in recent Project HARP firings. Designed and developed by Lockheed Propulsion Co. for Canada's Space Research Institute at McGill University, the rockets were not ignited in the Barbados Island launches. The tests were aimed at demonstrating the survivability of the propellant grain design and case bonding techniques developed at LPC. The Martlet 3-B's are 40 in. long, heavy-walled motors using end-burning grains. LPC has supplied light-wall motors 15 in. across and 75 in. long to McGill under another contract. These contain 600 lbs. of propellant. The main problem in gun-launching is supporting the propellant grain against the extremely high g-loadings.

British Aircraft Booster Unveiled

A retractable rocket booster unit, the BS 605, designed to assist in jet aircraft takeoffs is being marketed by Bristol Siddeley Engine Ltd. The all-liquid system uses peroxide and the aircraft's own kerosene fuel supply as propellants. These propellants are fed directly into the rocket's pump via the engine-mounting trunnions fixed to the aircraft. This eliminates any large flexible hoses. Compact dimensons have been achieved by arranging for the engine to pivot on the axis of the turbopump mounted across the unit. The entire unit retracts into the aircraft after use to avoid any drag penalties. Engine starting, stopping, lowering and raising is done electromagnetically. The engine can be fired only in the lowered position.

Hydrazine Auxiliary Engine to be Developed

Design techniques for monopropellant hydrazine rocket engines using the Shell 405 spontaneous catalyst over thrust ranges from 0.5 lb. to 100 lbs. are being developed by Rocket Research Corp. The Jet Propulsion Lab contract calls for the design, fabrication and testing of a series of engines with 0.5 lb., 5 lbs., 50 lbs. and 100 lbs. thrust.

The techniques developed will be applicable to both control rockets and gas generators. Another major design objective will be the establishment of criteria allowing the scaling up or down of rocket engines. Fast starts and shut-downs, reproducible pulses and reliable operation over extended usage are listed as design goals. Propellant mixtures having low freezing points will be included. Rocket Research has some six other contracts in the hydrazine control rocket area.

ELECTRONICS

Triggered Vacuum Gap Line Progresses at GE

A major advance in the design of high-voltage electronic switches described as a unique, new triggered-vacuum gap line will increase both reliability and performance while cutting down on maintenance, size and weight of sophisticated electronc equipment at General Electric's microwave tube business section. The cold-cathode devices, believed to be the first commercially available triggered vacuum gaps of their kind, were made feasible by the development of a hydrogen plasmoid injection trigger and gas-free, zone-refined metal electrodes. Primary use will be as an energy diverter to protect costly RF tubes. The devices can also be used to switch non-repetitive current pulses into low-impedence loads or energy storage capacitators into resistive or inductance loads. Possible applications include phased-array and other types of radar, and radiation-hardened exploding bridgewire circuits for missiles. The units will be marketed by GE's Electronic Components Div., Schenectady, N.Y.

MATERIALS

Superalloy Structural Shapes to be Extruded

TRW Materials Technology Lab of TRW Equipment Labs will extrude superalloys in structural shapes under an Air Force contract from the Materials Lab at Wright-Patterson AFB. Aim of the program is to develop manufacturing processes with the extrusion operation as the main forming step in producing structural shapes for jet engine ring applications on a reproducible and economical basis.

Avco/RAD to Study Gas Transport

A research program aimed at resolving the apparent discrepancy between the theoretically predicted and experimentally observed values of the thermal conductivity of nitrogen at temperatures between 10,000° and 20,000° K is in being at Avco Corp.'s Research and Advanced Development Div. The $60,000, one-year contract from NASA's Office of Advanced Research and Technology covers the study of thermal and electrical conductivity properties of gases at high temperatures. The primary lab tool used is a stabilized arc that permits continuous, high-resolution spectroscopic observations.

Deadline Draws Near in Competition For F-111 Digital Inertial Navigation Unit

HOLLOMAN AFB, N.M.—Competitive evaluation of digital inertial navigation systems for the Mark II avionics system for the F-111 aircraft is now entering the home stretch.

Aim of the test program is to select a system that will overcome the toughest problem in air-to-surface missile operations—minimizing positional and velocity uncertainties in an aircraft while it is releasing missiles.

For a number of the first F-111 aircraft, an analog inertial navigation system supplied by Litton Industries, the LN-14, has already been selected. It, however, is being put through the same tests as the five competing digital systems: the Autonetics N-16, the AC Spark Plug AN/ASM 47 Carousel, the Bell Hipernas 3, the Nortronics NIS 105, and the General Precision Mark II LCI.

The tests are being conducted by the Guidance Test Deputy at Holloman for the Systems Engineering Group, Research and Development Division, Wright-Patterson AFB, Ohio.

Requirements for entering the tests amounted to being able to put forward an operational navigation system before May 1, 1965. The staff at Holloman was surprised to find that instead of the 12 systems they had expected, only five were able to make the deadline.

● **No provision for trouble**—The end of the flight test phase of the systems evaluation is scheduled to be reached by September 15. Because it makes no allowance for major upsets in the test schedule, the stipulated 20-week testing period is thought to be somewhat optimistic.

The schedule is made up of three phases: initial bench tests that include measurement of Earth-rate, 23 hours of testing in a C-130 transport aircraft, and 42 hours of testing in an F-106 fighter aircraft. Each phase must be completed in turn, but there is no specified time for completion of any one phase. A manufacturer is not necessarily penalized for delays in getting to the last phase. The critical requirement is to complete all phases by the September deadline. One system has entered phase 3; several are in phase 2.

It is possible that no single system will be chosen outright from the present tests. Instead two systems may be selected for a run-off competition involving more detailed tests.

Normally Holloman would have preferred 35-50 hours of transport time and 70-75 hours of fighter time. To meet schedules the testing time has been cut to somewhat less than half this.

"Although these tests are being run on a shorter time period than usual, this is not to say we will not get a comparison of the systems," said Col. Charles E. Carson, who heads the office of Deputy for Guidance Test at Holloman. "We will be in a position to do more refined tests once a certain system has been chosen. This is what we hope to do. But we will not come out with the wrong system."

An important advantage to the Air Force of these tests is that it obtains experience of the operational capabilities of a navigational system without committing itself to buying in quantities.

There is close cooperation between the Holloman staff and the manufacturers whose systems are being tested. Each system has assigned to it an Air Force analyst, systems engineer, and airman technician. Each manufacturer provides factory training for the engineer working with its system. Holloman personnel do all the test work. Manufacturers adjust and service their equipment between tests.

● **The tests**—In the first phase of the tests, a systems integration check is made and systems calibration carried out. A static navigation run is then made. A system must display a specified accuracy in this run before passing on to Phase II.

"Phase I is not tough—just a simple test in which the system has to track mother nature," commented Col. H. F. Guffey, head of the Guidance and Control Directorate at Holloman. This is actually the simplest type of test for a navigation system.

In the flight tests, two types of mission are flown—performance, and operational. The first are designed to give information about the various error sources in a system, the second indicate how the system performs in typical operational flights.

In performance evaluation, east-west and north-south runs are desirable, and in operational missions a knowledge of east-west performance is desirable. These flight directions are obtained in flights from Holloman to Green River, Utah, in the north, and to Fort Huachuca, Ariz., in the west—one-way distances of 400 and 500 miles.

Another form of performance test is to fly at the inertial velocity of the Earth's surface at the latitude of the aircraft, bucking out inertial velocity. The aircraft is then standing still in inertial space and torquing errors can be separated. At Holloman this calls for aircraft flying at ground speeds of 760 knots.

During the test flights, the guidance systems indication of position is plotted for the systems engineer, and a plot of true position is transmitted up from the ground. This enables the systems analyst to keep a continuous error plot during flight, providing a quick check on gross errors. A period of a week to 10 days elapses before accurately reduced errors are obtained from the computer center.

● **Evaluation feedback**—Manufacturers are getting certain results that pertain to their own equipment. By agreement with Wright-Patterson, Holloman provides this information to the manufacturers directly.

In Phase III, the systems can only be flown two at a time. The F-106 performance missions are computer-designed to maximize the possibility of errors. Both high- and low-altitude supersonic missions will be flown, the latter to induce high-vibration loads.

The short time of the tests does not lend itself well to an accurate reliability determination, but Holloman is monitoring the tests with an eye on this aspect, to check the operational suitability of the system. ■

Evidence of Synergism Absent on GT-3

Scientists relieved by lack of amplified biological damage caused by interaction of space phenomena; final conclusions await further analysis

by Heather M. David

ONE OF THE EFFECTS of spaceflight biological scientists fear most has failed to appear in an experiment flown on *Gemini-Titan 3*.

The dreaded phenomenon is synergism—a situation in which two spaceflight parameters that might cause biological damage by themselves combine to produce damage greater than the sum of the two—in effect multiplying rather than adding.

The two influences most suspect if this should occur are radiation and weightlessness. However, it also has been demonstrated, and was the subject of a long Soviet paper presented in Paris in June, that radiation and acceleration produce unusual effects in combination.

Although the *GT-3* experiment results are only preliminary and it is only one short experiment, the news is being taken as a fortuitous sign for manned spaceflight. Much more detailed and longer-duration experiments will be undertaken on this subject in the *Biosatellite* program (M/R, Feb. 22, p. 34).

● **Experiment described**—The experiment flown on *GT-3*, designed by the Atomic Energy Commission's Oak Ridge National Laboratory for NASA, consisted of a device to irradiate human blood samples. It was actuated by one of the astronauts after the acceleration phase of the flight ended and weightlessness began.

Two of the experimental devices were shipped to Cape Kennedy before the flight, one to be placed on the right hatch of the *Gemini* spacecraft, the other to remain in the hangar at the Cape during the flight.

Ten samples of blood were contained in each unit. At the initiation of the weightlessness period, the astronaut twisted the handle of the unit, placing the blood samples between the radiation sources provided in the unit. These administered a dose of approximately 2 rad by phosphorus 32 beta rays. The ground control was handled in the same manner, at almost the exact time.

Each of the units contained 20 1x 6-mm cylindrical fluoroglass dosimeters, two each within each of the 10 blood samples. These recorded the dose administered by the source during the flight. In addition, there were two larger block dosimeters in each instrument package. These measured non-electron background radiation.

A few minutes after recovery of the spacecraft, the device was removed and color film records taken out and developed. The blood samples were put in tissue culture about 6 hours after the spacecraft landed. Later, cultures from both control and flight devices were fixed and chromosome preparations were made.

● **Results**—The film records proved that temperature was within reasonable levels, reaching a level of 90°F during assembly and staying within 58° and 100°F during the entire operation. The control device stayed somewhat cooler, between 34 and 84°F. Other instruments showed that the proper time duration for the radiation exposure was achieved.

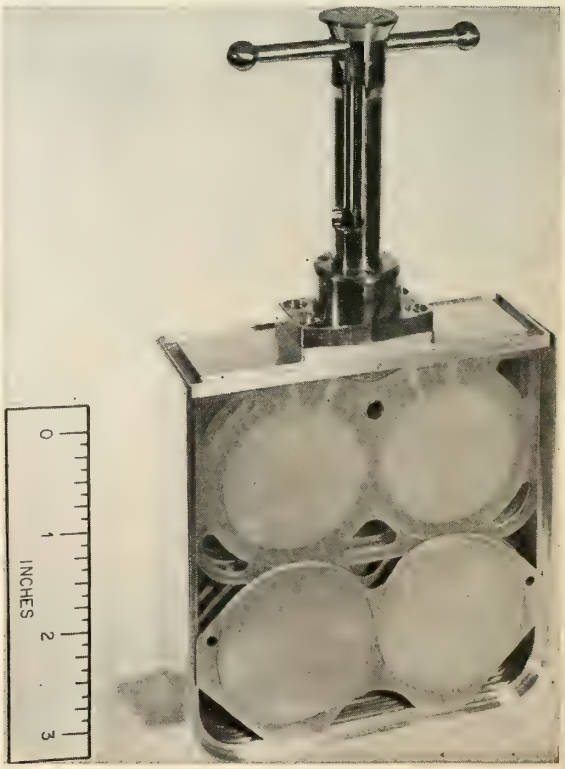
Radiation in the approximate 2-rad dose was a result of Bremsstrahlung with a peak energy of about 65 KeV, the flight package being slightly higher than the control because of ambient radiation encountered by *GT-3*.

Of the five dose groups, only two have now been fully analyzed. In the control groups, however, the aberrations are about those expected for such a low-radiation dose, and are the same as those measured in previous control experiments. In the flight samples, the frequency of chromosome-type deletions were somewhat, but not significantly, higher than the ground control samples.

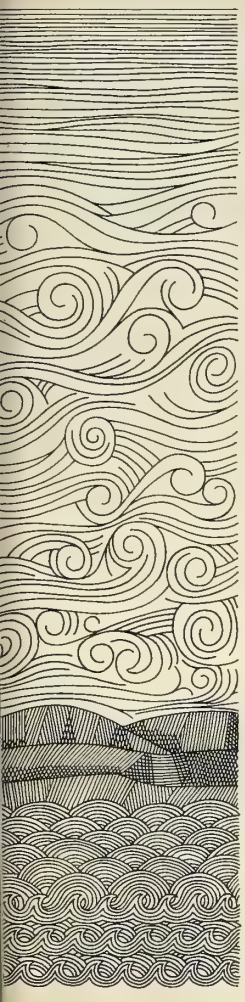
The preliminary conclusion is that the S-4 experiment failed to support the hypothesis that there is a synergistic effect of radiation and any other spaceflight parameter.

Blood samples also were taken from the flight crew before and after the flight. These also showed no increase in aberration frequency. ■

OAK RIDGE-DESIGNED device was used aboard Gemini-3 to test effects of radiation on human blood in weightless state.



WHERE CAN MAN GO...IN VEHICLE SYSTEMS?



Following the genesis of an idea, after theoretician and researcher have had their say, there results an end product from all that has gone before...a vehicle system. At Lockheed, these vehicle systems represent a deep corporate commitment. A commitment to extend mankind's capabilities both upon and above this planet in the years to come. For example, under the surface of the sea, one Lockheed vehicle system, known as Deep Quest—an extremely advanced two-place deep submersible—will explore the ocean depths. For land, Lockheed is using computers to design highly specialized vehicle systems for missions of the future. And in the infant realm of space, so recently within the first-hand investigative reach of man, Lockheed's Agena booster and spacecraft is already the most versatile vehicle system of the age. Now, scientists and engineers experienced and interested in a broad spectrum of vehicle systems, for all environments, are invited to write Mr. K. R. Kiddoo, Professional Placement Manager, Sunnyvale, California. Lockheed is an equal opportunity employer.

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Firm Develops Means for Electroforming Rocket Engine Chambers and Nozzles

by John F. Judge

OPERATIONAL rocket combustion chambers and nozzles can be grown in one piece for both liquid and solid propellant applications through electroforming techniques developed by Camin Laboratories, Inc.

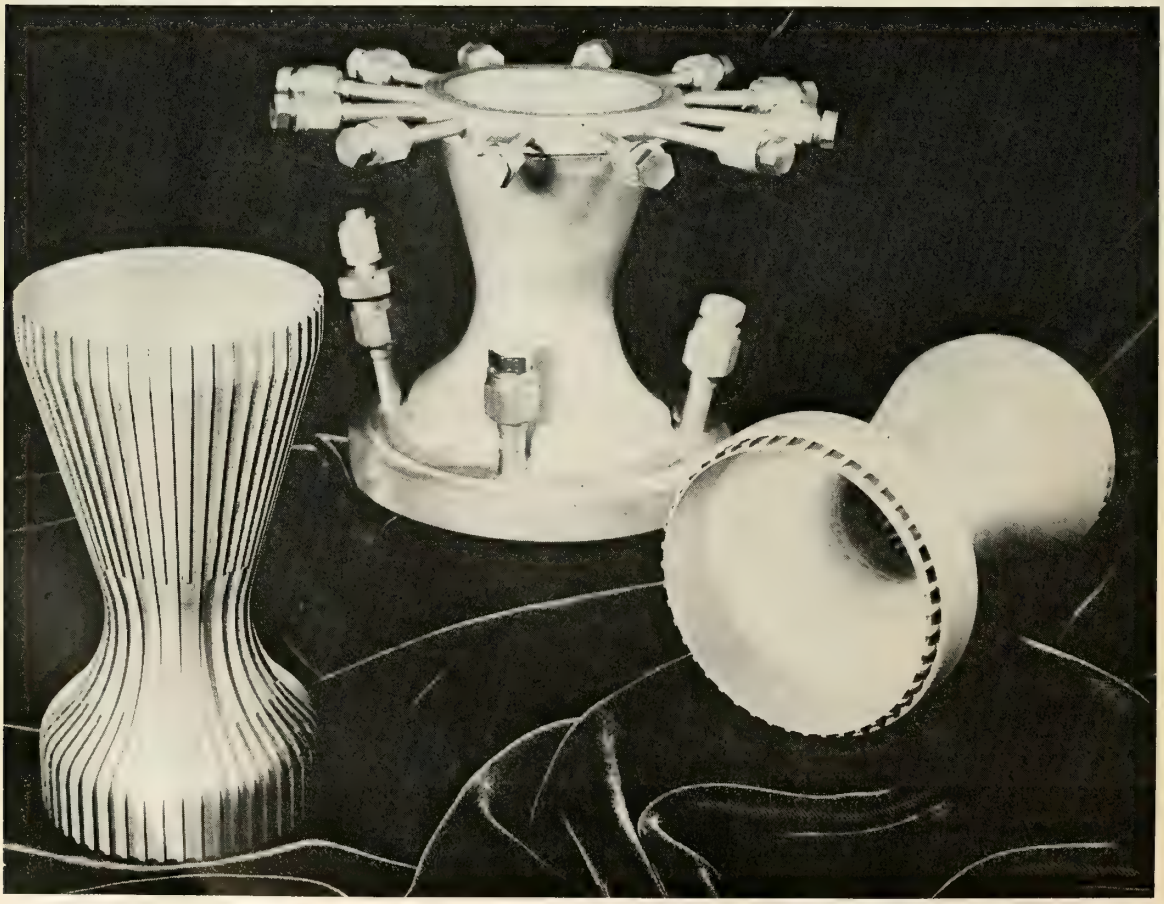
The approach results in thin-walled one-piece thrustors with built-in cooling passages and eliminates costly and complex welding and machining operations.

The Camin method has been investigated by all the major government propulsion centers—the latest being the Rocket Propulsion Lab at Edwards Air Force Base. Samuel Fialkoff, Camin vice president, says the electroforming ability to turn out intimate thin-wall and rib structures in a component permits operational uses not normally associated with electroformable metals—nickel, for instance.

In one case, a Camin-built water-cooled engine at Edwards is used as a test bed for various propulsion programs. It operates at combustion temperatures up to 8,000°F. The coolant pressures can be much higher—up to 1,200 psi in some cases.

● **Process described**—Fundamentally, the electroforming process uses the same principles and methods as electroplating. Electroforming substitutes a mandrel for the plated surface

THREE MAIN electroformed components of an experimental rocket engine combustion chamber are shown. Inclusion of the ribs and then the joining of an outer shell to the ribs is now a matter of routine at Camin Labs.



and usually involves greater plating thicknesses.

Metals amenable to the process include nickel, copper, iron, silver, lead, tin, cadmium, zinc, cobalt, indium and chromium. Camin processing engineers have a demonstrated ability in combining dissimilar metals in monolithic components. In rocket engines, techniques perfected at the firm result in double-wall-jacketed cooling structures in almost any configuration. The technique is proprietary.

But Camin can build ribs in any direction integral with both the inner and outer walls of the structure. This ability is coupled to an expert understanding of the flow processes and pressure requirements in liquid- or gaseous-cooled rocket components.

Such complex structures, complete with flow passages, do not require any welds or brazing operations, and are completely integral.

The interior finishes on any electroformed component is as good as the surface finish on the basic mandrel. In addition, the process lends itself to good reproducibility in production runs since there is no mandrel wear.

Camin experts have been able to electroform directly onto ablative and other high-temperature substrates that form the inner walls of high-temperature combustion chambers and nozzles. There is also the possibility of electroforming a case and nozzle assembly around a solid rocket grain.

● **Various engines fired**—Fialkoff says Camin has demonstrated its ability in this area more than adequately. A number of completed projects reinforce this viewpoint.

TENSILE TESTS OF CAMIN RIBBED STRUCTURES

	TEST CONDITION	YIELD STRESS (KSI)
1	Test at room temperature	102
2	Anneal (1000°F) test at room temperature	35
3	Anneal with preload; unload; test at room temperature	32
4	Test at 1000°F	22
5	Anneal; cool; test at 1000°F	18.7

A variable-thrust, partially cooled chamber was fabricated for the Army's Picatinny Arsenal by Camin. The configuration consisted of a ceramic chamber liner, a silicone carbide nozzle and a radiation-cooled spun-tungsten exit cone. These were joined to a triple helix Camin-formed coolant passage. The project adequately demonstrated the feasibility of the approach to the Arsenal.

Camin has also electroformed the booster motor for the KD2B-1 Beech target drone under contract to the Navy Bureau of Weapons. The units were succesfully fired at the Naval Weapons Lab, Dahlgren, Va.

There were no malfunctions and thrust was sustained at a level compatible with systems specifications. Post-firing examination revealed no deterioration of the components and nozzle throat erosion was negligible.

A scale version of the 1.5-million-lb.-thrust F-1 engine (1:58) was electroformed at Camin for NASA's Marshall Space Flight Center. The water-cooled, bimetal scale model used passages that permitted the flow of coolant from the injector end to the nozzle end and return. Previous fabrication methods necessitated some 24 welded ribs, with a machined and split outer jacket welded into place.

The Camin model cut the number of such components to one, without any form of welding or heat joining. All sizes, finishes and dimensional accuracies were maintained. The engine performed satisfactorily.

● **Tired of R&D**—Fialkoff feels ready to move out of the research and development category and aim for production business. In line with this, the firm has developed a method to manufacture large numbers of small, attitude-control units, with the chamber and nozzle together in one piece.

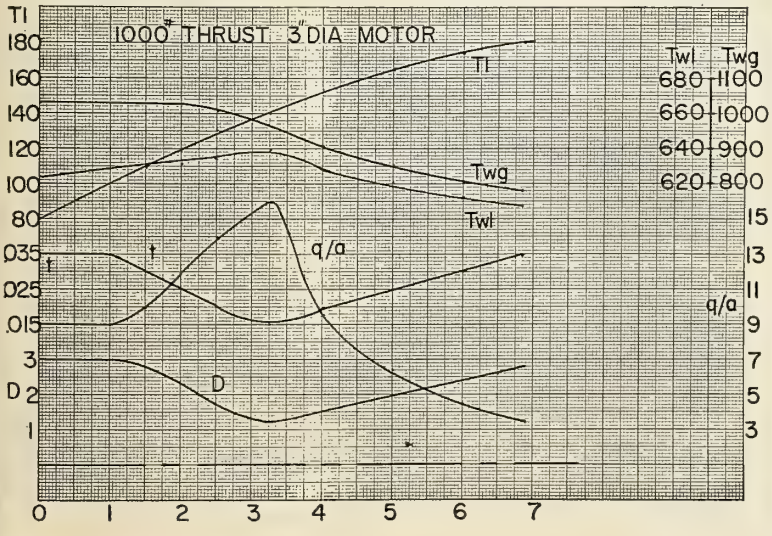
Camin engineers and technicians can build ports, orifices or whole injection assemblies into a thrustor. Besides the ability to work with dissimilar materials in the process, non-conductive materials can be included as integral components in a given structure.

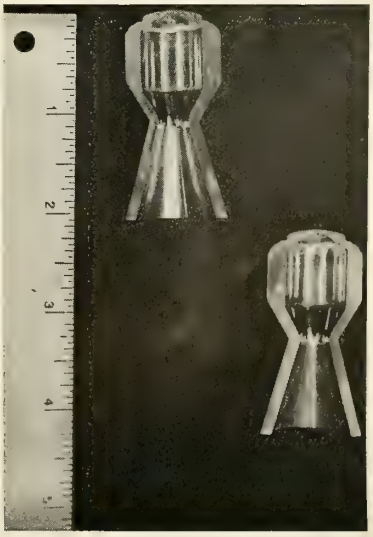
Electroforming can be used for arc chambers, wind tunnel nozzles, cavitating venturis, precision tubing, heat exchangers, tankage and wave guides in addition to combustion chambers, nozzles and injectors.

Camin Laboratories, Inc., originated production electroforming in the U.S. The process is being used for various industrial applications such as metal and plastic molds, precision tubing and various metal items demanding precise detailing in the finished product.

The firm has electroformed more than 40,000 small articles a week. The complex knowledge behind the chemical and electroforming baths—rates of deposition, mandrel forming and finishing, production scheduling and cost factors—is well developed at Camin. ■

LEFT: Performance of the 1,000-lb.-thrust motor now being used at Edwards as a test bed. T_l=liquid temperature; T_{wg}= wall temperature on gas side; T_{wl}= wall temperature on the liquid side; q/a=heat flux per unit area; and D=diameter. RIGHT: Uniform Micro-thrust motor assemblies such as these can be made at high rates through electroforming.





Gemini Fuel Filtration Solved

McDonnell minimizes particle contamination through use of chemically etched stacked discs; system flushing is sensitive

by Louis A. Mavros

Aerospace Ground Equipment Engineering Dept., McDonnell Aircraft Corp.

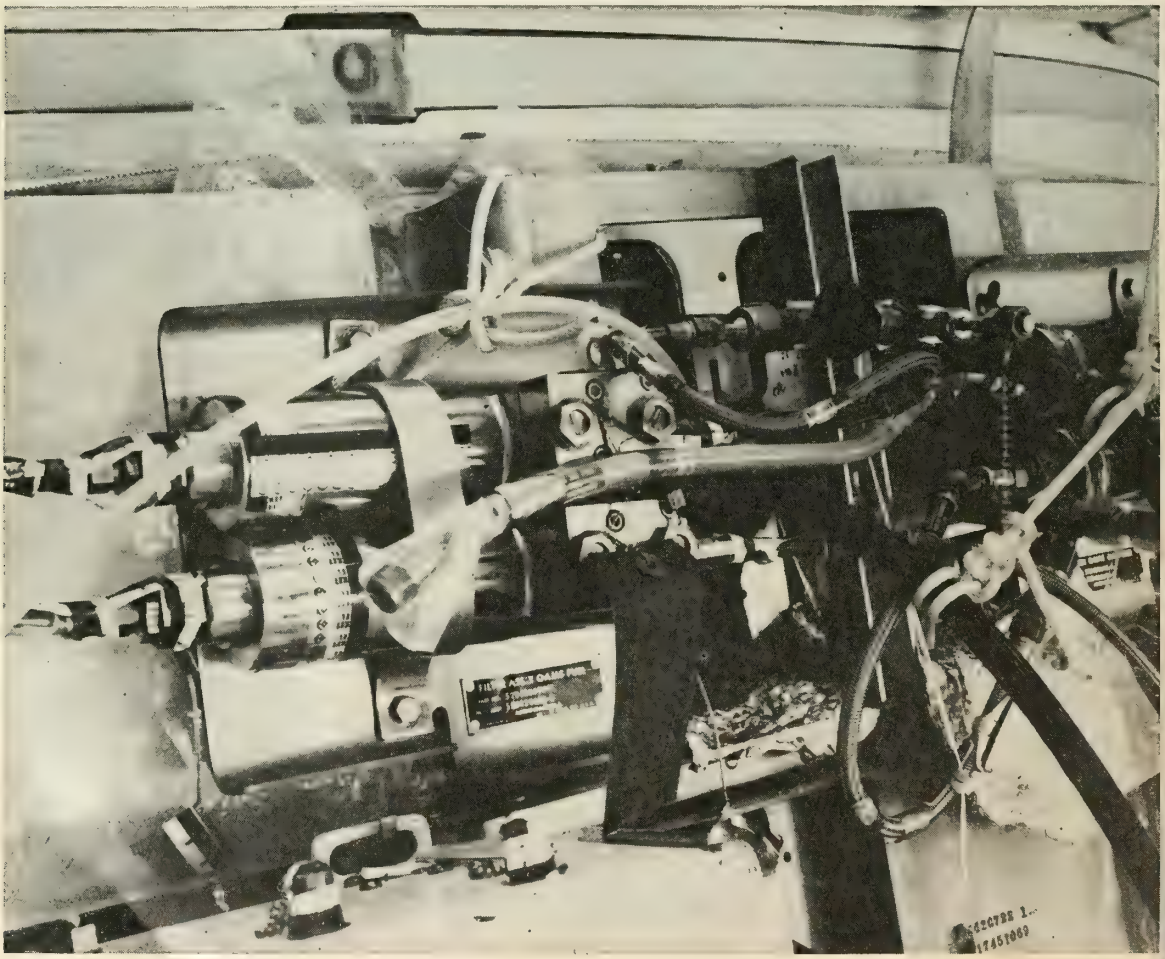
THE MOST IMPORTANT single factor that might cause faulty performance of the *Gemini* propulsion system is particle contamination. Failure analyses developed by McDonnell Aircraft Corp.—builders of the two-man spacecraft—point to this type of contamination as also affecting planning component and system overhaul.

Excessive particle contamination in the system increases wear and corrosion of system components and causes both seals and seats to malfunction.

Contamination in the propulsion system can clog filters and orifices, cause erosion in high-velocity helium systems and cause the solenoid valve in the spacecraft engines to stick or not seat and consequently not seal properly.

While contamination is a major factor in all critical fluid systems, it is particularly acute in *Gemini* because of the propellants—monomethyl hydrazine (MMH) and nitrogen tetroxide (NTO)—and the need for static testing.

THREE-MICRON filters function as a final screen for propellants. The chemically etched units are located to filter Gemini fuel just before it enters the servicing ports of the spacecraft. Each plate can be cleaned, and there is no filter migration.



In addition, the system, like any other, experiences self-generated particle contamination. This cannot be completely avoided, only minimized by materials selection, finishes and tolerances on sliding fits.

The last major source of particles is in the flushing fluids used to clean the system before and after gas testing for leaks, proof and function.

One of the problems with the *Gemini* craft in this respect is that airborne filters are welded into the various spacecraft components and cannot be replaced or cleaned after installation. These filters are 10 microns absolute and two microns nominal.

● **Filtering**—McDonnell engineers had to find a three-micron absolute filter with high dirt-holding ability and a low pressure drop, compatible with spacecraft propellants, to use as a final filter for fluids just prior to its entering the service ports of the *Gemini*.

Studies showed that most stainless steel mesh filters did not have a less-than-eight-micron screening ability. Paper, plastics or membrane filters were not compatible with the propellants.

The solution was a Vacco Valve Co. filter assembly consisting of multiple chemically etched discs stacked in a column. The process is accurately controlled and any level of filtration is determined by etching solution and bath time. Each plate can be cleaned and there is no filter migration.

The next problem was to determine an acceptable decontamination method and compatible flushing fluids. A complication here is the highly toxic nature of the propellants and the ability to introduce particle contamination through the decontamination fluids.

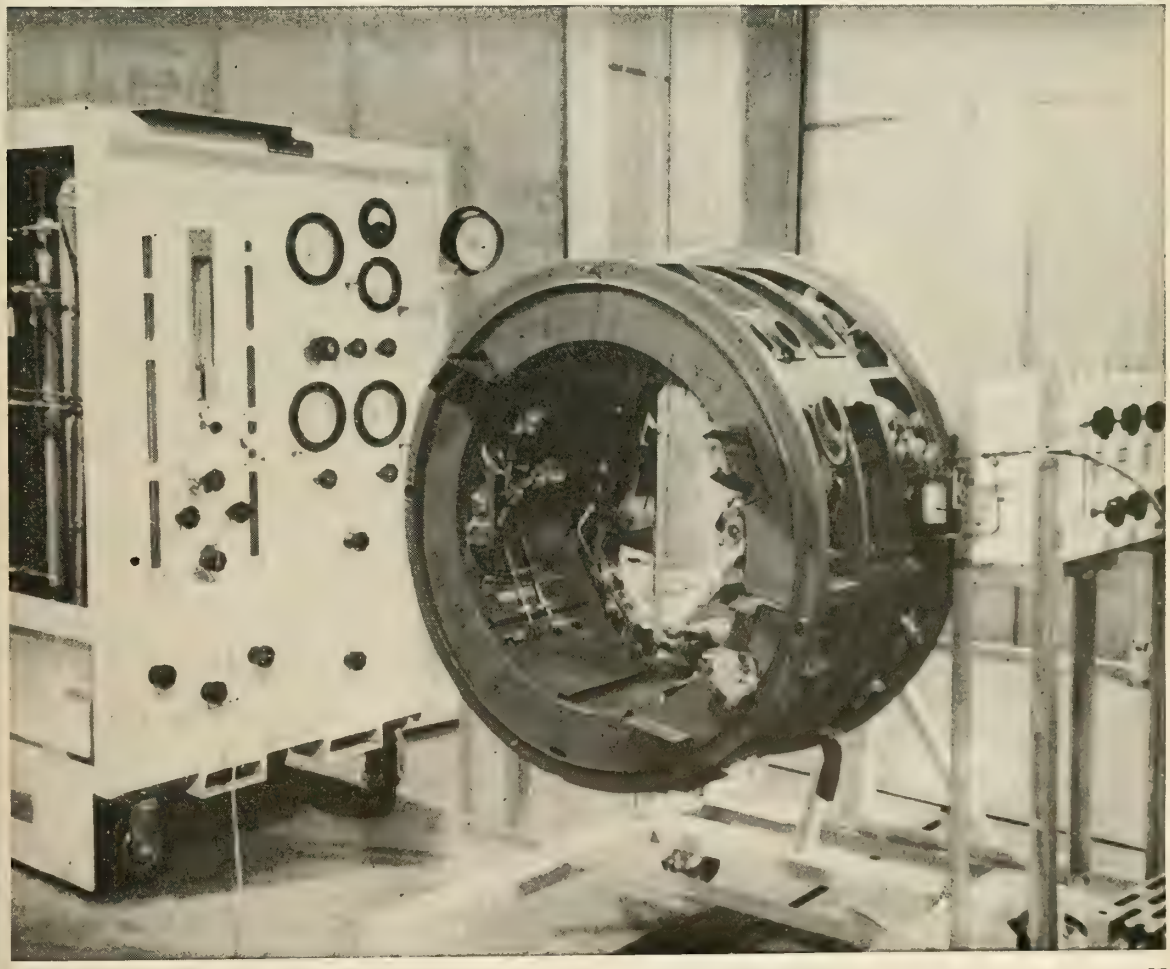
● **Toxicity**—The threshold value, which has been adopted by the American Conference of Governmental Industrial Hygienists, is 1 part per million (ppm) for MMH and 5 ppm for NTO. This is the maximum allowable concentration in which repeated eight-hour-per-day exposure may be safely tolerated by a human.

Minimum odor detection of MMH in air is approximately 3 to 5 ppm for the average man. Higher concentrations can cause immediate irritation of the eyes and nose. Continued exposure of test animals to hydrazine vapors produces lung damage, inflammation of the liver, inflammation of the kidneys, tremors, weakness, and—after prolonged exposure—convulsions followed by death. Data on the effect of hydrazine on humans is very limited.

Persons exposed to doses of NTO suffer effects similar to those associated with pulmonary edema, laryngitis, bronchitis and pneumonitis. This could be followed by difficult breathing and subsequent drowning in one's own exudate. All servicing and test personnel preparing the *Gemini* for flight must wear protective apparel with self-contained liquid air packs for protection from these toxic vapors.

Because of the toxicity problem, decontamination procedures and fluids

GEMINI re-entry control module is being serviced by McDonnel's AGE metering unit. A portable decontamination cart is airlifted to the Gemini recovery vessel to flush and seal the spacecraft before it is returned to Cape Kennedy after a mission.



had to be carefully selected to safeguard test and servicing personnel.

● **Tri-flushing**—At the beginning of the *Gemini* program, McDonnell used a tri-flush method for decontamination of the propellant system. The tri-flush method of decontamination consists of:

For the fuel system (MMH):

—Flush system with a mixture of 1 part hydroxyacetic acid, additives and 10 parts water;

—Flush system with methyl alcohol;

—Flush system with methylene chloride.

For the oxidizer system (NTO):

—Flush system with a mixture of 1 part triethanolamine, additives and 10 parts water;

—Flush systems with methyl alcohol;

—Flush system with methylene chloride.

The tri-flush procedure essentially neutralized the MMH and NTO with their respective first-flush solution. Each system was then flushed a second time with methyl alcohol to remove the water. The third flush, methylene chloride, was intended to help dry the system. The third flush liquid was to be purged from the propulsion system by heated gaseous nitrogen, GN_2.

Because of the many places the propellants and flushing fluids can be trapped in the spacecraft propulsion system, and the high boiling temperatures of the tri-flush fluids, it was almost impossible to dry the spacecraft completely. This introduced the possibility of contaminating the next propellant load with flush fluids.

● **Water problems**—After static firing of the spacecraft engine, it was discovered that the water was causing corrosion, and one of the additives—the anti-foaming agent in the neutralizer—was precipitating out of solution and appearing as particle contamination. The anti-foaming agent had an affinity for metal surfaces in that it would plate out in a monomolecular film. The second flush fluid then would cause the anti-foaming agent to coagulate.

During additional gas testing, some of the spacecraft engine valves failed to open and valve response was slow. Analysis revealed the cause of the failure to be a combination of corrosion caused from the water and excessive particle contamination from the anti-foaming agent.

McDonnell Aerospace Ground Equipment Dept. (AGE) engineers initiated a study program to find better procedures and flushing fluids for decontaminating the *Gemini* propulsion system. The parameters were (1) a flushing fluid relatively free from soluble and insoluble contamination, so as not to contribute additional particle contamination to the already critical spacecraft propulsion system, (2) a highly volatile flushing fluid, to achieve complete dryness of the spacecraft system with the aid of purging with ambient GN_2, and (3) a flush fluid compatible with the spacecraft propellants MMH, NTO, materials and lubricants.

The study for a new flushing fluid resulted in the application of a fluorocarbon solvent, trichloromonofluoromethane (DuPont's Freon MF). McDonnell engineering compared the effectiveness of Freon MF to that of the tri-flush method.

The first comparison of the Freon MF versus tri-flush method was an evaluation of particulate matter. The tri-flush commodities are procured on a commercial specification, allowing a high level of contamination. Freon MF is basically a cleaning solvent; soluble and insoluble residue does not exceed 2 ppm by weight.

AGE units used for the comparative tests of effective toxic decontamination and drying time were the fuel and oxidizer metering units. The metering units are normally used to fuel the spacecraft propulsion system with a known quantity of propellants within ±½% by volume. Another portion of the evaluation was to decontaminate an actual spacecraft system of its toxic residual with Freon MF.

The Freon MF outperformed the tri-flush fluids in all cases.

● **Freon tested**—Since monomethyl hydrazine and water form a hydrate residue, a final study was initiated to determine the amount of reaction between the monomethyl hydrazine and water content in the Freon MF.

The test consisted of three phases:

—Evaporation of 600 grams Freon MF in an inert atmosphere at ambient temperatures to determine the amount of residue in the test solution. The result was 0.0019 gram residue (0.0003% residue by weight). Residue from Freon MF came from the leaching of the plasticizer in the tygon tubing used for Freon transfer.

—Evaporation of 200 grams MMH under the same conditions as in Phase I. The result was 0.0519 gram residue (0.025% residue by weight).

—Evaporation of a mix of 600 grams Freon MF and 200 grams MMH under the identical test conditions as in Phase I. The result was 0.2594 gram residue (0.032% residue by weight).

The residue from the third phase is 0.007% more than the quantitative residue of Phases I and II. The amount of residue formed is highly soluble in H_2O and MMH, slightly soluble in isopropyl alcohol, and showed negligible solubility in Freon MF. The residue was analyzed by infrared spectroscopy.

Of this additional 0.007% residue, approximately one-fourth of the residue was found to come from a reaction between the MMH with the air, moisture and/or carbon dioxide. The remaining three-fourths of the 0.007% residue is a monomethyl hydrazine hydrochloride. The tests were performed in a glass beaker in which the complete test solution was evaporated and all the residue was contained.

● **Freon adopted**—Even under these adverse test conditions, the results were very favorable. The minute quantity of H_2O and MMH soluble residue that did form is dependent on exposure time, temperature and water content. The military specifications for MMH allows a moisture content of 2% maximum by weight. The manufacturer's specification holds the moisture content of Freon MF to 10 parts per million. DuPont, manufacturer of the Freon MF, claims its solvent can absorb a maximum of 85 ppm of water at 68°F.

During decontamination flushing of the spacecraft propulsion system, the MMH and NTO are displaced by the Freon MF, then the Freon is driven from the spacecraft system, and the system dried with dry GN_2 at ambient temperature. The exposure time during flushing is kept to a minimum. The mixture ratio of Freon MF and MMH during flushing far exceeds that of the 3:1 test ratio.

The Freon MF-MMH solution is driven from the spacecraft in a liquid state during the test, preventing even the minute quantity of residue that appeared during the test from forming in the spacecraft propulsion system.

The possibility of leaving an H_2O and MMH soluble hydrate in the spacecraft system is remote and the reactivity of minute hydrate particles is so low as to preclude any concern over the use of Freon MF.

The test results showed:

—Freon MF effectively displaces the MMH and NTO to a safe concentration level.

—The total soluble and insoluble residue content of Freon MF is 2 ppm by weight maximum, thus not contributing additional contamination to the already critical system.

—Freon MF is basically a cleaning solvent and will help dissolve and remove adherent and entrapped substances left from the propellant and/or gas testing.

Freon MF is very volatile, boiling point 74°F, and complete dryness of the system can be obtained in a very short time. Flushing fluids such as water, methyl alcohol and methylene chloride have a much higher boiling point and it is much more difficult to obtain system dryness with them. If complete dryness is not obtained, there is a good possibility the next propellant load will be contaminated by the flush fluids. ■

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Pending Shot May Seal SIGS Future

Aim of Navy program is to develop reliable inertial guidance package capable of being produced for $15,000 per copy

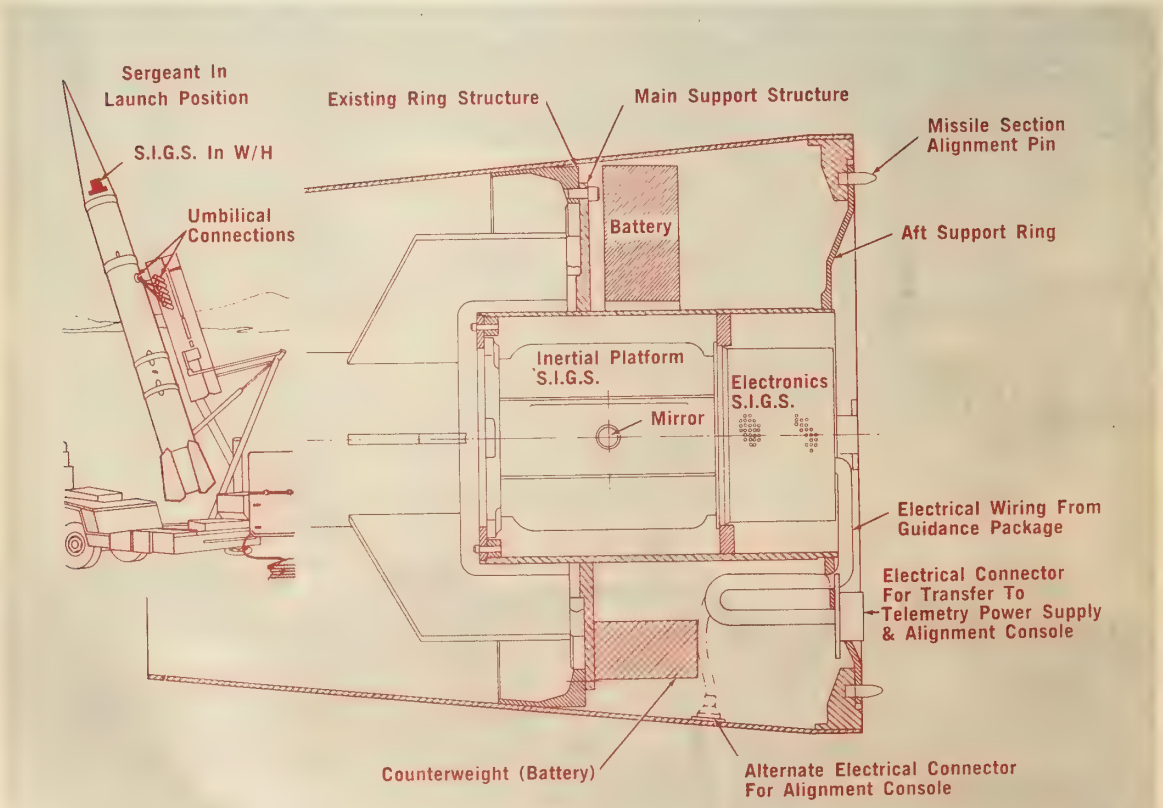
by Charles D. LaFond

THE NAVY'S Simplified Inertial Guidance System (SIGS) feasibility/development project has one primary goal—to build and flight-test a prototype guidance package capable of holding to an accuracy of two miles for three minutes of missile-guided flight with a platform costing no more than $15,000 in production (500 units/year).

The Bureau of Naval Weapons' W. B. Van Dusen, a technical director in the Missile Development Div., says the experimental system's future may ride or fall on only one flight test, now scheduled for Aug. 4 at White Sands Missile Range, N.M., aboard a *Sergeant* missile.

SIGS was designed and developed for BuWeps by the Norden Div. of United Aircraft Corp. under a $550,000 fixed-price contract. The Applied Physics Laboratory of Johns Hopkins University provided technical supervision and systems integration for the Navy. Sperry Utah Co., a division of Sperry Rand Corp. and prime contractor for the Army's *Sergeant* missile, is respon-

DIAGRAM OF SIGS system and its location aboard Sergeant launch vehicle.



sible for SIGS installation in *Sergeant* and for its flight test.

Test results will be analyzed independently by WSMR and APL.

● **Tri-service review**—The Navy will use SIGS to demonstrate one approach to the application of low-cost inertial guidance to its future tactical missile systems. While it is primarily intended for surface-to-surface weapons, other applications for SIGS have not been ruled out, said one official.

BuWeps initiated the project late in 1963 after performing considerable in-house feasibility studies through its engineering extension at APL in Silver Spring, Md. Proposals were received from 10 firms in December, 1963, according to Cmdr. J. L. Zelibar, SIGS project manager in BuWeps.

Norden was selected to develop SIGS after an unusual technical review of all proposals by experts from the Army Missile Command at Redstone Arsenal, Ala., the Air Force Systems Command at Holloman AFB, N.M., and BuWeps. The contract, awarded in March, 1964, called for delivery of the first unit by the following August and four more by January, 1965. Zelibar said the first was delivered on time, the last one month ahead of schedule.

● **Norden design**—Norden's approach is a single 54-lb. cylindrical package measuring 12 in. in diameter and 19 in. long. The three-gimbal stable platform is integrated with its supporting electronics, including an analog guidance computer.

BuWeps estimates that the Norden SIGS, using demonstrable production techniques, can be obtained for about $12,000 per unit at the rate of 500 per year. Recent Norden estimates, MISSILES AND ROCKETS has learned, are impressively lower—reportedly $9,600 per unit at the same production rate.

● **"Jittering-jewel" gyro**—Heart of the SIGS platform is the Norden RI-1000 floated integrating gyroscope. Dubbed the "jittering-jewel gyro," it employs an oscillating bearing to reduce friction on the output-axis suspension. A sleeve jewel, used as the primary support member, eliminates output-axis "stiction," Zelibar said, through the use of axial vibration of the jewel with respect to the ball pivot.

A ceramic crystal is used to drive the specially hardened sleeve bearing at the gyro-spin supply frequency. Zelibar said this reduces the friction level by a factor of 100 and improves gyro-drift performance by a factor of at least 5 (and possibly as high as 10). He emphasized the fact that this approach permits low-cost production of a relatively high-performance gyro and thus significantly reduces platform costs.

Other savings were obtained by using sand-coated gimbals having a single machined bore for pivot assemblies.

Separate gimbal pivot assemblies contain either a dual resolver or a torquer with their integral preloaded bearings. Alignment accuracy of the inner cluster is such that the platform gyros and accelerometers can be dropped in without adjustment, said Zelibar.

● **Two-part test program**—The first portion of the SIGS test program involved the determination of its cost and accuracy.

The cost-limit specification was met readily, according to Navy officials. Because it involved alignment at sea, the accuracy analysis required a considerable effort.

Early last January, SIGS was installed aboard the USS Compass Island and taken out to sea for a 10-day test period. During that time, it was aligned and operated 80 times and compared against the highly accurate *Polaris* submarine-type SINS (Ships Inertial Navigation System). Actual operating time totalled 40 hours.

Platform stabilization time and accuracy were found to be satisfactory and well within predictions. In addition, the Navy established the feasibility of aligning a low-cost inertial platform at sea.

The second—and final—part of the test program, actual flight test, is still pending. The Army has offered to fly the inertial system on a "space-available" basis open-loop aboard a *Sergeant* project evaluation missile. SIGS performance will be compared against the *Sergeant* inertial guidance and against WSMR tracking data.

First flight testing was scheduled for last March, but was scrubbed at that time because the Navy felt the system needed some modifications.

Several other flights also were cancelled because of lack of space in the *Sergeants* involved. The last scheduled attempt, on July 14, was frustrated by telemetry problems.

The flight profile will be similar to that of the Army's *Lance* missile, having a range of some 35 miles and a similar ballistic path.

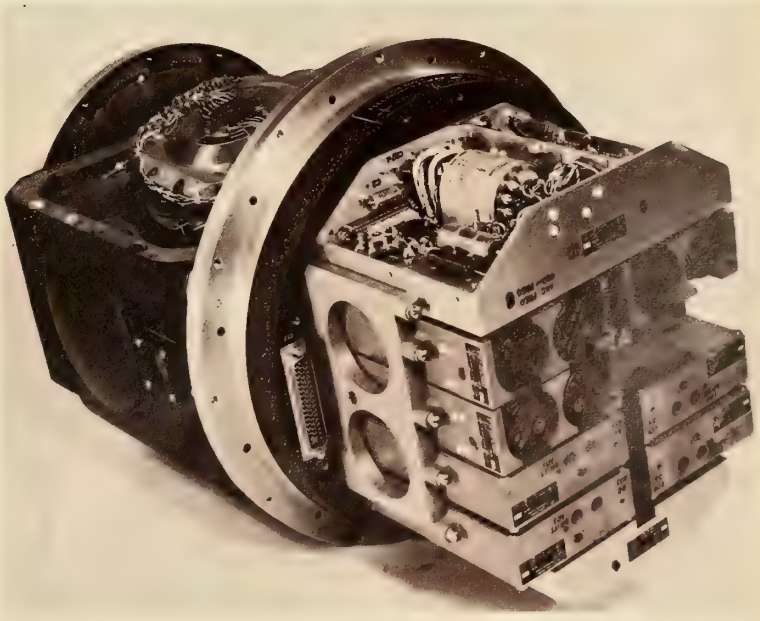
● **What next?**—The Navy is hesitant concerning what future applications of SIGS it may come up with if its flight test proves successful. Officials stress that SIGS represents only another building block on which it might build a core for Dept. of Defense support of a new missile system.

They also stress that SIGS merely points the way to one approach to a missile guidance system offering specific performance and cost figures. They have considered the *Lance* missile system's Autonet guidance, also a very low-cost approach.

They further note that if a new weapon system is funded for development, SIGS will only point the way. The contractor could go to a strap-down inertial system or to a completely reconfigured SIGS.

Nevertheless, insiders point out, Norden has built the SIGS and its estimated unit costs will be difficult to match. If SIGS' flight test proves satisfactory, it is expected that the Navy will increase its efforts to obtain DOD approval for a new short-range surface-to-surface tactical missile system. ■

ELECTRONICS section of Simplified Inertial Guidance System.



Physical Failure Studies Could Lead NAA Toward Second-Generation IC's

by Rex Pay

ANAHEIM, CALIF.—Bond failures in *Minuteman II* integrated circuits due to formation of an aluminum-gold compound have been discovered at North American Aviation's Autonetics Division, fabricators of the missile's guidance system.

As a result, integrated circuit manufacturers now supply their circuits with an intermediate refractory metal between each aluminum pad and the gold wire bonded to it.

The critical feature of this form of bond failure is that it slowly appears with the passage of time. Brittleness can develop and might go undetected until it causes a joint to fail under launch vibration. Then a missile that checked out well before launch might go haywire in flight, as its guidance computer puts out garbled instructions.

Detection of this bond defect and development of its remedy are held out as the most significant achievement to date of the physics of failure program Autonetics operates under contract to the Air Force Ballistic Systems Division.

● **Two-pronged approach**—The program has its own significance, too, particularly when coupled with an integrated-circuit processing study that Autonetics is carrying out for NASA's Electronics Research Center. Together, the two contracts suggest the division's preparedness to become a manufacturer of second-generation integrated circuits.

The alternative that either systems manufacturers must produce second-generation integrated circuits or that present IC manufacturers must become systems designers is clearly recognized by Dr. George Browning, technical director of the physics of failure program.

Typical experimental second-generation devices being made by Autonetics are metal-oxide semiconductor circuits with 800 devices per chip, and a "flip-chip" seven-bit counter containing 14 integrated circuits.

Browning pointed out to MISSILES AND ROCKETS that from a systems viewpoint it is essential to look at the total package. For the complex MOS networks that can now be put in a single package, this requires a systems capability to extend the functions across the chip, now that more and more functions are being put into one chip, he said.

The kind of know-how vital to this process, in Browning's view, is ability to optimize a design for system performance. He emphasized that this requires knowledge of failure processes and their impact on the system, and also knowledge of the influence of production processes—both of which are covered by the two Autonetics contracts mentioned.

● **Upgrading production**—NASA's Electronics Research Center contract involves a program to improve the reliability of integrated circuits by better production techniques. One of the aspects being studied is the nature of the oxide film on the integrated circuit and how its surface inversion characteristics are determined. Browning views this study as "of tremendous importance to MOS technology."

It is interesting that a systems manufacturer should obtain a contract of this sort. But the intense competition in integrated circuits and the importance of gaining several months' lead in highly proprietary production techniques may make component manufacturers wary of transferring part of their advanced research into the public domain.

Dissemination of production know-how to eliminate detected failure mechanisms forms an important part of the Autonetics physics of failure program. "This information is being supplied to vendors as fast as Autonetics scientists can get it to them, so that they can take corrective action," said Browning.

He pointed out that this cooperation is two-way. "There is no proprietary information that the vendors will not give us," he said, adding that the information reported to all vendors was the way to overcome a failure mode, not the identity of the vendor who was having trouble with that type of failure.

Physics of failure studies have been funded by Wright-Patterson AFB for about five years, but Autonetics has been the first to carry out the application of this concept at a systems level, Browning said. This application involves identifying the systems impact of different failure modes to schedule research so that it will have the strongest impact on system performance.

Application of physics of failure methods to this missile system was necessary because reliability tests for *Minuteman II* circuits of the type run for *Minuteman I* components would be too costly. The implication is that physics of failure studies will become even more important in systems making use of second-generation integrated circuits.

● **Failure analysis**—The philosophy behind the method is that most failures are not truly random but can be analyzed and corrected.

Procedure starts with the recognition and characterization of an abnormality in an integrated circuit. The abnormality is brought to the notice of the physics of failure team when it comes to light in the *Minuteman II* component quality assurance test program. A mechanism for the abnormality is then postulated and an attempt to verify the mechanism is carried out. When a mechanism is verified, corrective action is developed and the production information is sent to the manufacturers.

In the component quality assurance tests, vendors are step-stressing circuits with different types of stresses until failure occurs. They then check their manufacturing processes to see if they have a sequence in which the particular stress occurs at an intensity near to that causing failure.

The failures noted are reported to Autonetics' physics of failure team, which has about 45 scientists, funded at about three-quarters of a million dollars.

a special report: oceanology

the application of advanced technology to the oceans

There are virtually no differences in the advanced technologies used in "inner space" and "outer space." Good engineering is applicable to all technical problems, the only changes are in the parameters. ■ On September 6, 1965 MISSILES AND ROCKETS will publish a special report on Oceanology — stressing the engineering aspects of putting man and his instruments into the sea for its exploration and exploitation. Particular emphasis will be on current major programs, projects, companies and facilities and how they relate to expected needs of Oceanology for the late sixties and early seventies. ■ The Oceanology Special Report will cover: • Budget, Policy and Management • Materials in an Ocean Environment • Instrumentation and Data Collection • Surface Platforms • Submerged Platforms • Life Support Systems • Facilities

Publishing Date: September 6, 1965 **Advertising Closes: August 23, 1965**

Missiles and Rockets The Weekly of Advanced Technology

The team was formed about 9 months ago and has produced about 6 reports.

Many causes of failure have been examined. Minute strain gauges cemented to integrated circuits have revealed residual stresses in the silicon chip. Use of a ceramic brace is one remedy for this. Other abnormalities detected include traces of chloride contaminant, gold-tin braze voids, package contaminants, aluminum grain variations caused by non-uniform deposition temperatures, and glass cracks and voids blamed on faulty weld schedules.

Nanogram wet chemistry is being used to analyze microscopic abnormalities that appear on the surface of integrated circuits. Picogram techniques will ultimately be tried.

When the CQAT program showed an incidence of failure in gold-aluminum thermo-compression bonds, an investigation of gold-aluminum compounds formed by solid-state reactions was carried out. Five intermetallic compounds and two solid solutions were identified. "This gives you a feeling for how much is unknown," remarked Browning. He pointed out that to fully understand the time-temperature dependence of the processes taking place might cost more than the total weapon system itself.

● **Aim of the effort**—The steps taken by Autonetics were to note that intermetallic compounds could be formed and to recognize that these were brittle and had different volumes. Also their formation was time-temperature dependent. The effect of the brittleness could also be enhanced by the bond-forming process, which tended to leave a knife edge in which some migration could occur, giving an avenue of propagation for a crack.

Sections of many gold-aluminum bonds showed that an intermetallic compound could form as a layer between the gold wire and the aluminum pad to which it was bonded. The remedy suggested, therefore, was to insert a refractory metal or some other diffusion barrier between the gold and aluminum.

While the presence of "purple plague" has often been noticed in the past, it generally forms at temperatures above 250°C, and no trace of it was seen in joints failing due to brittleness, said Browning.

Some abnormalities identified are not associated with observed failure modes. If they lead to identification of a potential failure mode, a physics of failure analysis is carried out.

Abnormalities not associated with potential failure modes are also noted, to provide data for assessing the reliability of future devices. Such abnormalities are 50-Angstrom inclusions in silicon, or the occurrence of stacking faults at a p-n junction. ■

AF Lets Pact for Measuring Plasma Micro-Instability

PHYSICISTS at Sperry Rand's research center in Sudbury, Mass., will use the firm's thermally operated plasma system (TOPSY) to generate small-scale simulations of the high-temperature turbulent plasmas associated with thermonuclear fusion reactions.

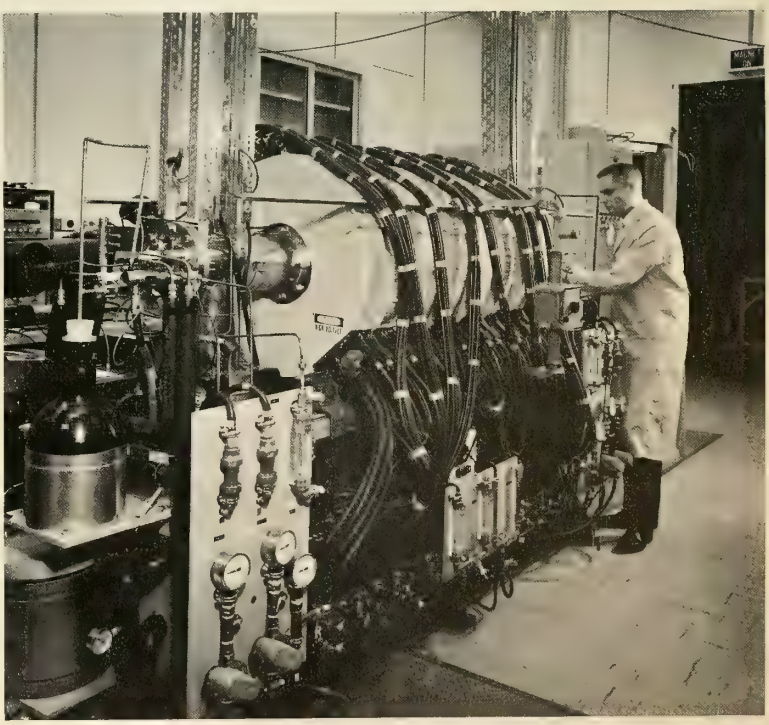
The work, being performed under a 1-year, $92,000 contract from the Air Force Office of Scientific Research, is aimed at simulation and measurement of the micro-instabilities associated with these plasmas and also at developing techniques for magnetically confining the plasma.

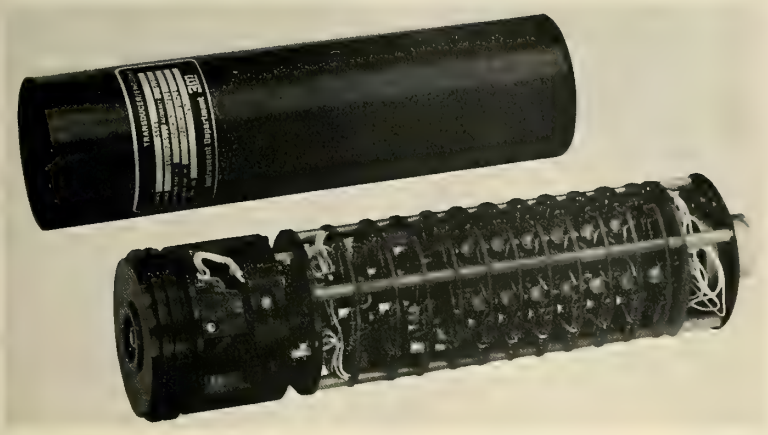
Sperry scientists estimate that generation of a full-scale controlled-fusion plasma would require a vacuum chamber 50 ft. long, a magnetic confinement field of more than 120,000 gauss, and enough electrical power to heat the plasma to fusion temperatures of 100,000,000°K.

Using the proper scaling factors, Sperry scientists believe that a close analog of the full-scale plasmas can be achieved using the 7-ft.-long TOPSY vacuum chamber.

The TOPSY system operates by low-energy thermal ionization of a stream of neutral cesium gas, in contrast to other plasma generators, which use high-energy electrical discharge for ionization. The ionizing device is a small tungsten-plate emitter at one end of the chamber that heats the cesium to 2,300° K. The system, which is surrounded by eight electromagnets, produces a 5-ft.-long plasma column of 10^8 centimeters^{-3} density at 2,300°K in a 6,000-gauss field, according to officials at Sperry Rand. ■

SPERRY RAND'S thermally operated plasma system.





New Product of the Week: Optical Shaft Encoder

An optical shaft encoder with non-ambiguous 1-2-4-8 BCD output has been developed by the 3M Co.

The Model 2035 is of all-silicon, solid-state construction and precisely divides one shaft resolution into 1,000 parts (12-bit BCD). The unit is mounted with a standard SAE #23 servo mount when used in heavy duty applications. A special instrument mount, having a torque of 0.1 gm-cm (0.0014 in.-oz.) is available for use with instruments which employ delicate shaft motion. Gated parallel and serial parallel with sample-and-hold electronic output packages are available.

Circle No. 151 on Subscriber Service Card

Relay Switch

A double pole throw JR relay, designed to meet MIL-R-5757/19 requirements, is being marketed by Branson Corp.

The unit offers voltage ranges of 6, 12 and 24v dc; corresponding coil resistances are 100, 400 and 1,600 ohms. Minimum operating life is 150,000 operations. Insulation resistance is 1,000 megohms at 25°C.

The relay operates over a temperature range of —65° to 125°C and withstands 30 g's at 10 to 300 cps vibration. Shock resistance is 100 g's for 11 millisecs.; acceleration, 150 g's.

Circle No. 152 on Subscriber Service Card

Standing-Wave Detectors

A series of standing-wave detectors for measurement of VSWR and relative phase of a selected load has been announced by TRG, a subsidiary of Control Data Corp.

The Series 741 devices permit measurement of both magnitude and phase of an unknown reflector coefficient. In measurement of VSWR, maximum power limitation of transmission lines is determined by the power-carrying capacity of the multi-hole directional coupler and the 3-db pad used in the secondary arm of the coupler.

The unit is a 10-db bi-directional coupler fabricated in two halves from tellurium copper. It is available in the 12 to 90-gc region.

Circle No. 153 on Subscriber Service Card

Quadrature Couplers

Advanced Development Laboratories, Inc., has available two precision 3-db quadrature couplers.

The Model 02-103 A operates from 260 to 850 mc; the Model 02-103 B operates from 800 to 2,500 mc. Coupling variation is ±0.5 db; insertion loss is less than 15 db. VSWR is 1.25:1 maximum.

Relative phase shift between outputs is 90 degrees or —5 degrees across the band.

Circle No. 154 on Subscriber Service Card

Rewindable Gyro

A stored-energy gyro which can be rewound without removing the cover has been announced by Electronics Div. (Portland) of Electronic Specialty Co.

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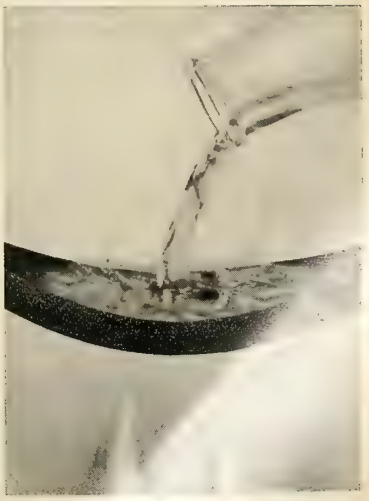

Circle No. [illegible] Service Card

The 1.5-lb. unit, designated Type NF 6010B, is used to provide course or attitude reference. Energy is supplied from a spring to bring the gyro up to running speed in less than 60 milliseconds. Speed is maintained by an a-c induction motor; potentiometer pick-off is provided. The unit can withstand 10 g's acceleration from 10 to 2,000 cps and 60 g's shock for 0.01 second. Rewinding and rearming is accomplished by rotating the cover a quarter turn to expose the winding mechanism, then winding with a standard Allen wrench. Dimensions are 2.25 in. maximum diameter x 3.5 in. length.

Circle No. 155 on Subscriber Service Card

Tape Transport System

A digital magnetic tape transport system, designed to military specifications for shipboard installation, missile bases and and trailer-mounted applications, has been introduced by Potter Instrument Co., Inc.

The Model SC-1150M is a single-capstan tape transport with an operating capability at bi-directional tape speeds to 150 ips at 800 bpi with no program restrictions.

The device is able to withstand 50 g's shock; MTBF exceeds 1,000 hours with 10° start/stop operations. Other specifications include a start time of 3 millisecs., stop time of 3 millisecs., and dynamic I.C.T.D. of less than 1.5 microsecs.

Circle No. 156 on Subscriber Service Card

Electro-Dynamic Shaker

An electro-dynamic shaker with a force of 15,000 lbs. is being marketed by Ling Electronics, a division of LTV Ling Altec, Inc.

The Model 335 features hydrostatic bearings for reduced cross-axis motion and an armature re-centering system. The system will support test loads of up to 1,000 lbs. without external load support, the firm says. The armature is capable of attaining a 100-g acceleration level with a 60-lb. load.

Circle No. 157 on Subscriber Service Card

Capacitor Bank

A series of high-voltage capacitor banks, offering a source of high-energy storage and fast risetime discharge capabilities, is available from Advanced Kinetics, Inc.

The Series HVCB-10 offers energy storage modules from 3,000 to 21,000 joules in 3-kilojoule steps and from 21,000 to 100,000 joules in 10-kilojoule steps. Energy is stored at 10 kilovolts dc (20-kv units available upon request). Each 3,000 module has a risetime of less than 4 micro-secs. and develops short circuit currents up to 100,000 amps. Three models are available with 1 pulse/5 minutes maximum, 1 pulse/1 minute maximum and 6 pulses/1 minute maximum.

Circle No. 158 on Subscriber Service Card

Mass Spectrometer

A general-purpose mass spectrometer, the Type 21-104, has been introduced by Consolidated Electrodynamics Corp., subsidiary of Bell & Howell Co.

The device is useful for qualitative and quantitative analyses of gas, liquid and certain solid samples and provides a mass range of m/e 1 to 2,000. Resolution without an electron multiplier exceeds 1/600. With a multiplier, resolution is 1/1,500 (10% valley definition).

The unit is constructed with a pull-out/tilt-up chassis for accessibility, a "C" shaped magnet and a 24-hr. liquid N_2 cold trap.

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This light weight stainless steel fire extinguisher container is one of many APCO fire bottles made in a range of sizes, shapes and fluid media for aircraft and auxiliary power equipment. All these units are giving dependable service on both military and commercial aircraft produced by Boeing, Lockheed, Convair, Northrop and others.
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Circle No. 4 on Subscriber Service Card

RF Amplifier

Resdel Engineering Corp. is marketing a wideband power amplifier, the Model 91289.

The device features a linear gain of 20 db minimum over a frequency range of 150 kc to 25 mc. The front panel contains 50-ohm input and output Type N connectors, RF power output meter and primary power controls. The unit contains its own regulated solid-state power supply and is available as a bench instrument or for rack mounting.

The device is designed to be used for stringent electromagnetic interference measurements (EMI Spec. No. 279, MSFC) and is useful in testing sweep frequency interference characteristics of ground systems and aerospace components, the firm says.

Circle No. 160 on Subscriber Service Card

Vacuum Ionization Control

A high-vacuum ionization guage control covering a vacuum range down to 10^{-8} torr is being marketed by National Research Corp., a subidiary of Norton Co.

Major applications of the Model 720 include vacuum metalizers, thin-film and integrated circuit coaters, electron beam welders and space simulation and research chambers. It can be used with any resistance outgassing ionization gauge tube, developers say.

The transistorized device weighs 12 lbs. Combination of a logarithmic scale and linear scale provides the entire span of pressure on a single meter. A finer emission adjustment allows for control from zero to 10 milliamps

Circle No. 161 on Subscriber Service Card

Tachometer Tester

A portable instrument to test and calibrate tachometers is being marketed by Kahn & Co., Inc.

The Model KC-1713 uses a potentiometer type of speed setting and has a full operating range of from 200 to 6,400 rpm. Output shaft speeds (of the variable speed drive) in excess of 1,600 rpm are obtained by use of a flexible tachometer cable with ratio sections of 1:2 and 1:4.

Accuracy of the device is ±1% full scale. A 0.2% tachometer generator output is available as an option for digital readout. Power requirement is 115v, 60 cps.

Circle No. 162 on Subscriber Service Card

Differential Transformer

Kavlico Electronics, Inc., is marketing the Model GM4037 linear variable differential transformer.

The device is 0.125 in. in diameter and 0.125 in. long. It can measure displacements from 10 microinches to 0.025 in., with infinite resolutions, the firm says. Output impedance is less than 3 ohms; input is lv at 30 kc.

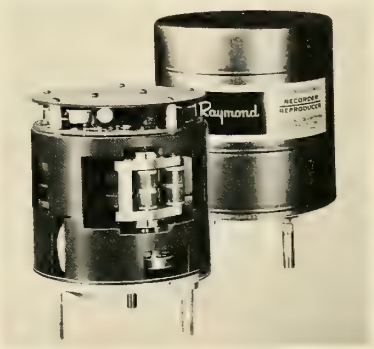
The unit has a standard temperature range of −65° to 275°F. Special-design units are available for operation from −420° to 500°F.

Circle No. 163 on Subscriber Service Card

Rocket Recorder

A compact recorder, designed to record and reproduce FM and digital data through all phases of rocket flight, has been announced by Raymond Engineering Laboratory, Inc.

The Model 1849 measures 4 in. in



diameter and 4 in. high and weighs 2.8 lbs. Environmental specifications include: shock, 50 g's, 11 ms and 500 g's, 1.5 ms; vibration, 20's RMS, random band limited to 2,000 cps; 10 g's RMS sine 30 to 2,000 cps; 1.5 minutes sweep duration; sustained acceleration, 200 g's along axis; 150 g's across axis; temperature range, 32° to 160°F; altitude, unlimited.

Other specifications include a tape capacity of 113 ft. of 1-in., 1-mil Mylar tape; recording time of 45 secs. @ 30 ips; tape speeds of 30, 15, 7.5 or 3.75; and tape speed accuracy of ±0.5%.

Circle No. 164 on Subscriber Service Card

Log Amplifier

A wideband logarithmic amplifier with an extended range of from 200 mc down to 20 kc is being marketed by Kay Electric Co.

The Model 1025-B Logafier gives an over-all response while providing detailed measurements of points on the curve as far down as 80 db. It provides internal switching to set up either the full band of 20 kc to 220 mc, or a faster responding band of 200 kc to 220 mc.

Other specifications include a flatness of 500 kc to 100 mc ± 0.5 db and 20 kc to 220 mc ±1db; logarithmic accuracy of ±2 db; input impedance of 50 ohms and output load of 50 ohms.

Circle No. 165 on Subscriber Service Card

Digital/Synchro Converters

Astrosystems, Inc., is marketing a line of digital-to-synchro converters featuring single-speed resolution and accuracy to 5 seconds of arc.

The series A702S units accept computer input angles in parallel binary or BCD form and convert these inputs to 3 or 4-wire analog outputs capable of driving synthros and/or resolvers. Maximum updating rate is 500 words per second. Output angle can be changed 180 degrees in less than 2 milliseconds.

Standard models are available as transmitters or receivers with resolutions of 13 to 18 bits and accuracies equivalent to ±0.5 bit. Power requirement is 115 v with 60 or 400 cps, 0.25 amp.

Circle No. 166 on Subscriber Service Card

Vibrating Reed Electrometer

A vibrating reed electrometer with a built-in recorder is being marketed by Applied Physics Corp.

The Model 3810 has a building-block design for attachment of accessories for radio-respirometry studies of small animals, tritium-air monitoring and high-temperature radio-activity-chromatography.

The unit has a sensitivity of 10^{-17} amps, 5 x 10^{-16} coulombs or 0.02 millivolts. The recorder has eight chart speeds, selectable from the front panel. Accessories include an air dryer and animal cage, a special ionization chamber and a high-temperature oven with a temperature range from ambient to 300°C.

Circle No. 167 on Subscriber Service Card

Tunnel Diode Amplifier

Micro State Electronics Corp. is marketing a multi-stage tunnel diode amplifier with a gain of 50 db.

The solid-state Kμ-band assembly is designed to operate over a frequency range of 15 to 16 gc. Gain varies less than 1 db from the rated 15 db over a temperature range of 15° to 45°C. Noise figure characteristic is typically 6 db over the operating band.

Other amplifiers in the series are available at frequencies up to 18 gc.

Circle No. 168 on Subscriber Service Card

Air Traffic Control

people needed in MITRE's Washington, D.C. office to provide system engineering assistance to the Federal Aviation Agency. Work areas include broad level system design, computer program operational specification, configuration management, system integration and system test planning.

Communications

people needed who can help conceive new communications systems, recommend development programs, and analyze special communications requirements generated by new systems concepts. Work areas include systems planning, range instrumentation, tactical air control and survivable communications.

National Military Command System

people needed for systems analysis and feasibility studies, communications systems analysis, systems design, integration, and verification.

Sensor Systems

people needed to support theoretical and experimental programs on advanced radar and optical detection and tracking systems; feasibility and technique analysis, systems synthesis and performance evaluation.

Computer Programming

people needed with experience in the development and support of monitors, compilers, real-time simulations, time-sharing systems, etc.

Systems Analysis

people with experience in military systems or operations analysis with a background in physics, mathematics, operations research, or industrial management.

Systems engineers needed for work on these vital projects

MITRE works on the basic design and general system engineering of complex information, control, sensor, and communications systems of national importance. An important part of its mission is the development of new techniques in these areas and advancement of the general technology. If you have three or more years' experience and a degree in electronics, mathematics or physics, write in confidence to Vice President — Technical Operations, The MITRE Corporation, Box 208G, Bedford, Mass.

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The Industry Week

Mergers and Acquisitions

LTV Electrosystems, Inc., Greenville, Texas, is acquiring certain assets of LTV Military Electronics Div. and all outstanding stock of LTV Continental Electronics companies from the parent corporation, Ling-Temco-Vought, Inc., Dallas. In separate transactions, LTV Ling Altec, Inc., Anaheim, Calif., will acquire LTV University Div., and an equipment line from Menasco Manufacturing Co. The firm's Ling Electronics Div. is purchasing the Micro Gee line of motion simulation equipment. . . . *Beckman Instruments, Inc., Fullerton, Calif., is in the process of acquiring Industrial Instruments, Inc., Cedar Grove, N.J., manufacturer of precision measuring and control instrumentation. Plans call for exchange of 77,341 shares of Beckman common stock for the assets of Industrial Instruments. The transaction is subject to approval by Industrial shareholders.* . . . Eberbach & Son Co., Ann Arbor, Mich., and its subsidiary, K & L Scientific, Inc., Columbus, Ohio, have merged with Will Scientific, Inc., Rochester, N.Y. Will Scientific is a supplier of laboratory equipment and reagent chemicals. . . . *Canoga Electronics Corp., Chatsworth, Calif., has acquired the assets of Remanco, Inc., Santa Monica, Calif. Both firms manufacture telemetry, radar and digital systems and components for missile/space applications.* . . . The G. T. Schjeldahl Co. of Northfield, Minn., has purchased for cash the Camblock and Gorn divisions of Newal, Inc., New Milford, Conn., as well as Glasseal Products, a subsidiary of Newal. Camblock and Gorn make electronic connectors for missile, aircraft and computer applications. Glasseal manufactures hermetically sealed components and connectors designed for a variety of special applications. Schjeldahl, whose activities have been limited to making balloons for atmospheric and space research made the purchase as part of its recent efforts to expand into the electronics industry.

Glass Fiber Price Fixing Charged

Six manufacturers of glass fibers for aerospace and missile programs have been charged with price fixing by the Federal Government. Named as defendants in the civil suit are Burlington Industries, Inc.; J. P. Stevens & Co.; United Merchants & Manufacturers, Inc.; and Clark Schwebel Fiber Glass Corp., all of New York. Also accused are Exeter Manufacturing Co. of Exeter, N.H., and Coast Manufacturing Co. of Livermore, Calif. The Government charges that the concerns held secret meetings in several locations in New York for "forming and effectuating" the alleged conspiracy. No specific damage figure is mentioned in the suit, but it is believed that it could run into millions of dollars. In earlier criminal court action, in the same area of complaint, the companies and several of their corporate officers paid a total fine of $106,000.

New Activities

Aerojet-General Corp., El Monte, Calif., has given division status to two of its subsidiaries—Aerojet-General Nucleonics, San Ramon, Calif., and Aerojet-General Shipyards, Jacksonville, Fla. Purpose is to improve the company's overall competitive position and simplify administrative procedures. . . . *P. L. Howard Associates, Inc., a consulting firm, has been established in Centreville, Md., by Dr. Paul L. Howard, Sr. The firm will cover the fields of energy conversion, power sources, electrochemistry, oceanography and desalinization. Howard is a director of Yardney Electric Corp., New York City.* . . . Scientific Data Systems, Santa Monica, Calif., has changed the name of its subsidiary, Consolidated Systems Corp., to SDS Data Systems. It is based in Pomona, Calif.

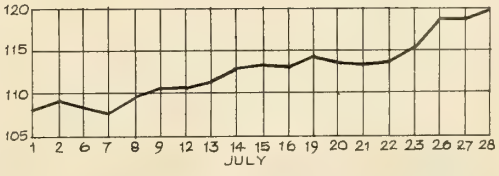
Electrical, Electronics Organizations Merge

The Electronic Industries Assn. and the National Electrical Manufacturers Assn. will form a joint committee to study means of coordinating service in areas of mutual interest. A resolution adopted by directors of both associations cites "ultimate merger as a desirable goal, but not excluding lesser cooperative steps in the short term."

Facility Expansions

Federal Electric Corp., service associate of International Telephone and Telegraph Corp., will negotiate with the Atomic Energy Commission to provide support services at the commission's Hanford plant near Richland, Wash. The contract would total approximately $15 million annually for five years. In meeting an AEC objective to bring new business to the area, FEC would establish a west coast division in Richland. . . . *Henley & Co., New York City, has added facilities to provide custom-made maser and laser single crystals in a variety of materials, including Al_2O_3, TO_2, carbonates, garnets, vanadates, carbides and nitrides. Henley & Co. is an international supplier of high-quality chemicals and materials for the electronics market.*

Missile/Space Stock Index



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

contracts

AIR FORCE

$24,839,500—**Federal Electric Corp.,** Paramus, N.J., for maintenance and operation of the Defense Early Warning System, with work to be done in Canada, Alaska and Greenland.

$9,000,000—**Dynalectron Corp.,** Washington, D.C., for aircraft and missile maintenance and modification.

$8,530,750—**General Electric Co.,** Syracuse, N.Y., for space tracking facilities.

$6,600,000—**General Electric Co.,** Philadelphia, for work on the Mark 12 re-entry program.

$7,348,960—**Kollsman Instrument Corp.,** Elmhurst, N.Y., for AN/USQ-28 spare parts and aerospace ground support equipment.

$4,046,000—**Aerospace Corp.,** El Segundo, Calif., for general systems engineering and technical direction of ballistic missile and space programs.

$3,500,000—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., to test and evaluate advanced warhead fuzing and arming concepts.

$2,600,000—**General Telephone & Electronics Corp.,** Sylvania Electric Products Inc., Mountain View, Calif., for refinement and operational testing of electronic security systems to help guard *Minuteman* ICBM sites.

$2,419,000—**Atlantic Research Corp.,** Alexandria Va., to produce meteorological sounding rockets.

$2,000,000—**Aerojet-General Corp.,** Azusa, Calif., to design and manufacture radiometric equipment.

$2,000,000—**Marquardt Corp.,** Van Nuys, Calif., for flight test of supersonic ramjet engines.

$1,485,803—**The Bendix Corp.,** Baltimore, for communications equipment.

$1,639,304—**International Business Machines Corp.,** Washington, D.C., for electronic data processing equipment.

$1,468,610—**Collins Radio Co.,** Richardson, Tex., for communications systems.

$1,391,721—**General Dynamics Corp.,** Convair Div., San Diego, to produce orbital vehicles and related equipment.

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$1,358,500—**Hoffman Electronics Corp.,** El Monte, Calif., for communication equipment for aircraft.

$1,350,202—**Kollsman Instrument Corp.,** Standard Kollsman Industries, Inc., Elmhurst, N.Y., for spare parts for mapping and survey systems.

$1,327,278—**Aerojet-General Corp.,** Downey, Calif., for solid-propellant hazards program and critical diameter of solid rocket motor propellants.

$1,260,000—**Douglas Aircraft Corp.,** Missile and Space Systems Div., Santa Monica, Calif., for *Genie* rocket motors.

$1,197,944—**Martin Co.,** Denver Div., Denver, for analytical investigations of air-augmented rockets to determine thrust minus drag.

$587,637—**Hercules Powder Co.,** Wilmington, Del., for chamber gas secondary injection thrust vector control for high-performance solid-propellant rocket motors.

$587,395—**International Telephone and Telegraph Corp.,** ITT Gilfillan Inc., Los Angeles, to improve the operational capabilities of Mobile RAPCON.

$545,000—**Bell Aerosystems Co.,** Buffalo, N.Y., for feasibility demonstration of advanced maneuvering-satellite attitude-control system.

$493,586—**North American Aviation, Inc.,** Canoga Park, Calif., for demonstration of high-chamber-pressure toroidal combustor segment for liquid rocket engines.

$459,000—**TRW, Inc.,** Systems Group, Redondo Beach, Calif., for study of space propulsion systems experiments utilizing environmental research satellites.

$445,000—**Yardney Electric Corp.,** New York City, for an extremely high-voltage missile power supply.

$412,689—**TRW, Inc.,** Systems Group, Redondo Beach, Calif., for maneuvering-satellite wide-range flow control.

$407,000—**United Aircraft Corp.,** United Technology Center, Sunnyvale, Calif., for demonstration of an advanced solid-propellant propulsion system.

$283,769—**Dynatronics, Inc.,** Orlando, Fla., for manufacture and installation of an automatic tracking antenna at Point Pillar, Calif.

$263,711—**Thiokol Chemical Corp.,** Huntsville, Ala., for development of a process for rigidized tooling for internal shapes of solid propellant motors.

$260,022—**United Aircraft Corp.,** United Technology Center, Sunnyvale, Calif., for demonstration of a multiple ignition device for use with a re-startable solid motor.

$245,194—**Acoustica Associates, Inc.,** Los Angeles, for development of a cryogenic propellant management system.

$239,000—**General Telephone & Electronics Corp.,** Sylvania Electric Products Inc., West Roxbury, Mass., to operate and maintain a transportable satellite communications terminal at Model City, N.Y.

$199,324—**Aerojet-General Corp.,** Von Karman Center, Azusa, Calif., for combustion study of high-energy gelled fuels.

$125,000—**University of Tennessee Space Institute,** Knoxville, for investigation into the basic physical phenomena involved in the process of converting the energy in a flowing plasma stream into electrical energy.

ARMY

$17,865,016—**Raytheon Co.,** Andover, Mass., for *Hawk* missile system ground support equipment.

$15,700,000—**Dynalectron Corp.,** Washington, D.C., for three years of data collection at White Sands Missile Range, N.M.

$7,500,000—**Telecomputing Services, Inc.,** Panorama City, Calif., for three-year continuation of services for reduction of missile-in-flight and other test vehicle data for Army, Navy, Air Force and NASA at White Sands Missile Range.

$5,583,300—**Richardson-Merrell, Inc.,** Philadelphia, for continuation of a classified program.

$2,495,798—**Raytheon Co.,** Andover, Mass., modification for *Hawk* engineering services.

$1,320,000—**Dynalectron Corp.,** Washington, D.C., for development and manufacture of various mechanisms.

$1,203,984—**Belock Instrument Corp.,** College Point, N.Y., for six *Hawk* simulator stations.

$1,066,563—**Westinghouse Electric Corp.,** Defense and Space Center, Surface Div., Baltimore, for pulse doppler measurement kits and digital ranging systems.

$834,800—**Smith and Sapp Construction Co.,** Orlando, Fla., to construct a universal environmental shelter at the *Titan III* Launch Complex 41.

$775,489—**Cubic Corp.,** San Diego, to update digital data-handling equipment used in *SECOR* satellite surveying program.

$455,890—**Douglas Aircraft Co.,** Santa Monica, Calif., for 8 months research in optical systems.

$448,122—**Martin Co.,** Orlando Div., Orlando, Fla., contract extension for a program to analyze the nation's air-defense network.

$388,903—**General Precision Inc.,** Link Group, Palo Alto, Calif., for modification and fabrication of a synchronization and control system.

$299,965—**Sperry Rand Corp.,** Sperry Utah Co. Div., Salt Lake City, for a closed-circuit television system in NASA's Manned Spacecraft Operations Building on Merritt Island, Fla.

$224,000—**Geo.-Space Corp.,** Melbourne, Fla., for infrared tracker.

$203,000—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., to demonstrate the feasibility of utilizing Avco/RAD-developed penetration aids on tactical missiles.

$183,751—**Honeywell Inc.,** West Covina, Calif., for *Redeye* trainer.

$150,000—**Heliodyne Corp.,** Los Angeles, for eight-month research in re-entry physics.

$137,804—**Chromcraft Corp.,** St. Louis, Mo., for rocket launcher.

$129,323—**General Electric Co.,** Utica, N.Y., for optical contract correlation seeker.

$127,600—**Beech Aircraft Corp.,** Wichita, Kan., for *MQM-61A* target missile flight services.

$97,516—**Canoga Electronics Corp.,** Chatsworth, Calif., for mobile telemetry acquisition system.

$63,250—**Raytheon Co.,** Wayland Laboratory, Wayland, Mass., for 12 months research in the field of electronic counter-countermeasures.

$45,795—**Astrodata Inc.,** Anaheim, Calif., for electronic trajectory system.

$42,833—**Craig Systems Corp.,** Lawrence, Mass., for shelters for *Pershing* missile system.

$31,419—**Braddock Dun and McDonald, Inc.,** El Paso, Tex., for study of *Nike-X* system effectiveness against hostile ICBM and SLBM payloads.

NAVY

$23,800,000—**General Dynamics Corp.,** Pomona, Calif., for pilot production of medium-range standardized missiles.

$17,000,000—**Hughes Aircraft Co.,** Culver City, Calif., for *Phoenix* missile systems.

$15,929,496—**Vitro Corp. of America,** Silver Spring, Md., for engineering and logistic support for *Polaris* missiles.

$13,500,000—**Sperry Rand Corp.** Sperry Gyroscope Co. Div., Great Neck, N.Y., for continued work on *Polaris* submarine navigation systems.

$12,395,020—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for engineering and logistic support for *Polaris* missiles.

$8,493,656—**Northwest Marine Ironworks,** Portland, Ore., to build two oceanographic research ships.

$7,170,000—**Sperry Rand Corp.,** Syosset, N.Y., for work on *Polaris* missiles.

$5,000,000—**Ryan Aeronautical Co.,** San Diego, for design and an initial quantity of a supersonic version of the *Firebee* jet target drone.

$4,720,475—**Lockheed Aircraft Corp.,** Lockheed Missiles & Space Co., Sunnyvale, Calif., for repair of *Polaris* hardware.

$2,570,400—**ITT Gilfillan, Inc.,** Los Angeles, for a data programming unit.

$2,056,955—**Motorola, Inc.,** Scottsdale, Ariz., for guidance and control systems for *Sidewinder* missiles.

$2,009,400—**Chromcraft Corp.,** St. Louis, Mo., addition to existing contract to make *Mighty Mouse* rocket launchers.

$1,700,000—**Electronic Specialty Co.,** Los Angeles, for telemetry equipment.

$1,454,340—**Baifield Industries, Inc.,** Carollton, Tex., to make target launchers.

$1,426,794—**Dynatronics, Inc.,** Orlando, Fla., for the manufacture and installation of five automatic tracking antennas.

$1,128,707—**Northrop Corp.,** Nortronics Div., Anaheim, Calif., to provide logistic and engineering services for the *Polaris* missile.

$900,000—**Texas Instruments, Inc.,** Dallas, for services and materials in connection with development of the *Shrike* system.

$700,837—**General Electric Co.,** Tempo Div., Santa Barbara, Calif., for study of requirements for future ASW data collection and analysis systems.

$498,200—**Westinghouse Electric Corp.,** Underseas Div., Baltimore, to construct a Mk 48 torpedo research facility at Naval Torpedo Station, Keyport, Wash.

$474,272—**North American Aviation Inc.,** Autonetics Div., Anaheim, Calif., for study to improve the Mk 2 Mod 3 ships inertial navigation system for *Poseidon* application.

$434,154—**Aerojet-General Corp.,** Sacramento, Calif., for research and development of a throttleable liquid rocket motor.

$223,000—**Philco Corp.,** Sierra Operations/Communications and Electronics Div., Menlo Park, Calif., for modification of equipment to make a transportable 500-kw communications amplifier.

$100,000—**Aerojet-General Corp.,** Sacramento, Calif., for supporting engineering for the improved *Tartar* motor and the missile flight and ground-test program.

$99,772—**Perkin-Elmer Corp.,** Norwalk, Conn., for a laser measurement system.

$97,547—**General Electric Co.,** Missile and Space Div., Philadelphia, for fabrication, test and delivery of solid-propellant electric-thruster flight units and engineering performance data.

NASA

$5,000,000—**Fairchild Hiller Corp.,** Space Systems Div., Rockville, Md., to provide engineering services in support of Goddard Space Flight Center's Systems Integration and Sounding Rocket Div. for two years.

$2,830,459—**Dow Chemical Co.,** Midland, Mich., for continuation of facilities engineering support services for one year at Kennedy Space Center.

$2,460,000—**North American Aviation Inc.,** Space and Information Systems Div., Downey, Calif., for preliminary definition study for utilization of command/service module for *AES*.

$1,580,000—**Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for Phase B LEM utilization for *AES*.

$1,500,000—**Consultants & Designers, Inc.,** New York City, for scientific and engineering support services.

$1,210,000—**Aerojet-General Corp.,** Sacramento, Calif., for secondary propulsion system engine restart capability study.

$1,288,889—**Utronics Inc.,** Utica, N.Y., for communication stations.

$1,174,518—**General Electric Co.,** Military Communications Dept., Oklahoma City, Okla., for Mark 1 ranging subsystems to be used in analyzing the flight of such spacecraft as *Mariner* and *Apollo*.

$1,100,000—**Scientific Data Systems,** Santa Monica, Calif., for computers and peripheral equipment.

$1,096,000—**Comcor, Inc.,** Anaheim, Calif., for development of a hybrid simulation system.

$1,000,000—**McDonnell Aircraft Corp.,** St. Louis, for refurbishment and modification of *Gemini-2* capsule.

$600,000—**Canoga Electronics Corp.,** Chatsworth, Calif., for a high-performance antenna tracking system at the Merritt Island *Saturn* Launch Complex.

$582,811—**TRW, Inc.,** Systems Group, Redondo Beach, Calif., for launch support and operations in connection with *Atlas-Agena*.

$410,000—**University of Michigan,** Ann Arbor, for program for measuring the structure and variability of the upper atmosphere of the Earth.

$405,051—**Aerojet-General Corp.,** Solid Rocket Operations, Sacramento, Calif., for demonstration of a solid-propellant motor malfunction-detection and combustion-termination system.

$370,000—**Motorola, Inc.,** Military Electronics Div., Scottsdale, Ariz., for *Apollo* S-band rendezvous system.

$350,000—**North American Aviation, Inc.,** Los Angeles, for research and development for fabricating a simulated titanium alloy "Y" ring segment for *Saturn* S-1C fuel tank.

$274,290—**Hercules Powder Co.,** Cumberland, Md., for X-258 propellant characterization study.

$270,000—**Martin Co.,** Denver Div., Denver, Colo., for on-board checkout system for *AES*.

$206,080—**Ampex Corp.,** Redwood City, Calif., for expansion of the Videofile document storage and retrieval system obtained by NASA in 1964.

$196,000—**Energy Systems, Inc.,** Palo Alto, Calif., for TV S-band system transmitters.

$191,479—**Douglas Aircraft Corp.,** Missile and Space Systems Div., Huntington Beach, Calif., for *Saturn IB* improvement study, solid first stage, Phase II.

$185,000—**Honeywell, Inc.,** Aeronautical Div., Minneapolis, for development of *Apollo* Block 1, Block II and LEM ACA devices.

$168,652—**Watkins-Johnson Co.,** Palo Alto, Calif., for design, fabrication and delivery of S-band power amplifiers.

$157,570—**Electro Mechanical Research Inc.,** Sarasota, Fla., for study of lunar geophysical surface and subsurface probes for *Apollo Extension Systems*.

$124,603—**General Electric Co.,** Missile and Space Div., Philadelphia, for study of thermal protection requirements for a lifting-body entry vehicle suitable for near-Earth missions.

$123,950—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., for development of typical Mars landing-capsule sterilization container.

$101,477—**General Dynamics Corp.,** Fort Worth, Tex., for design, development, fabrication, test and delivery of two flight models of a special rate-of-separation measuring device of two stages of a space vehicle.

$99,817—**Bell Aerosystems Co.,** Buffalo, N.Y., for continuation of the study of zero-gravity positive expulsion techniques.

$86,000—**General Electric Co.,** Philadelphia, for study of a gravity-gradient stabilized *Nimbus* spacecraft.

$81,850—**North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., for study of mass loading effects on localized vibratory rocket vehicle environments.

$79,900—**North American Aviation, Inc.,** Space and Information Systems Div., Downey, Calif., for design criteria for guidance flight mechanics and trajectory optimization.

$73,000—**TRW, Inc.,** Systems Group, Redondo Beach, Calif., for evaluation of semi-action gravity-gradient system.

$67,397—**General Dynamics Corp.,** Convair Div., San Diego, for development of analytical method for predicting residual cryogenic propellant behavior in orbital vehicles.

$54,350—**Lockheed Missiles and Space Co.,** Palo Alto, Calif., for study of super-orbital entry heating problems.

$50,000—**Marquardt Corp.,** Van Nuys, Calif., for gravity-gradient boom and material study.

$49,300—**General Electric Co.,** Tempo Div., Santa Barbara, Calif., for analytical approach to the large solid rocket motor reliability and test program.

INDUSTRY

$8,480,697—**Chromcraft Corp.,** St. Louis, from **Army** and **Air Force** for work on *Mighty Mouse* rockets.

$7,000,000—**Douglas Aircraft Co., Inc.,** Santa Monica, Calif., from **North American Aviation Inc.,** Downey, Calif., for production of a propellant utilization system for the S-II stage of *Saturn* launch vehicle.

$1,800,000—**Menasco Manufacturing Co.,** Burbank, Calif., from **The Boeing Co.,** Seattle, to test and produce a liquid spring shock isolation system to be used in underground installations at *Minuteman* Wing VI.

$1,500,000—**Electro-Optical Systems Inc.,** Micro Systems Inc., Pasadena, Calif., from **North American Aviation Inc.,** Space and Information Systems Div., Downey, Calif., to provide temperature and pressure transducers for *Apollo*.

$600,000—**Quantic Industries,** Pelmec Div., San Carlos, Calif., from **Thiokol Chemical Corp., Aerojet-General Corp.,** and **Hercules Powder Co.,** for production of safe-arm igniter mechanisms for *Minuteman*.

$312,000—**Electro-Optical Systems, Inc.,** Micro Systems, Inc., Pasadena, Calif., from **Marquardt Corp.,** Van Nuys, Calif., for advanced semiconductor pressure transducers to be used aboard the LEM.

$144,188—**Trans-Sonics, Inc.,** Burlington, Mass., from **The Boeing Co.,** Seattle, to provide electronic equipment for the Slosh Measuring System in S-1C *Saturn* booster stage.

missiles and rockets
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names in the news

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J. B. Keating: Appointed manager of missile systems at Douglas Aircraft Co.'s Washington, D.C., office.

Martin J. Conway: Joined Electro-Tec Corp. as executive vice president and general manager. He was formerly with Honeywell, Inc.

Dr. A. J. Boyd: Elected to the board of directors of the Armed Forces Communications and Electronics Assn. He is president of Radiation Inc.

Dr. Werner R. Kirchner: Appointed assistant general manager of Aerojet-General Corp.'s Sacramento Plant. He is a vice president of the corporation.

J. L. Clark: Appointed manager of program and management analysis for Sylvania Electronic Systems, a division of Sylvania Electric Products, Inc.

James E. Webb: Named as an honorary chairman of the Robert Hutchings Goddard Library Program at Clark University. Named as chairmen in addition to the NASA Administrator were **Mrs. Robert H. Goddard, Lowell Thomas, Dr. Charles G. Abbot** and **John Jeppson.**

John L. Platner: Awarded the Allis-Chalmers 1965 Scientific and Engineering Award for inventing the "static moisture control concept" of removing water and waste heat from fuel cell electrical power systems that run on hydrogen and oxygen. He is manager of the company's fuel cell development program for NASA.

Henry Burlage, Jr.: Joined Jet Propulsion Laboratory as deputy manager of propulsion. He was formerly chief of liquid rocket research and technology for NASA Headquarters.

H. G. Irwin: Named director of the *Voyager* spacecraft program at Douglas Missile & Space Systems Div. He was formerly deputy director of advanced medium launch vehicles.

Dr. Norman M. Wiederhorn: Appointed general manager of GCA Corp.'s Viron Div. He was formerly director of the Applied Science Laboratory, GCA Technology Div.

Capt. William E. Benbow: Presented the Legion of Merit "for exceptionally meritorious conduct in the performance of outstanding service during the period December 1961 to April 1965 while serving as Commanding Officer, U.S. Naval Guided Missiles School, Dam Neck, Virginia Beach, Va."

Dr. Harper Q. North: Elected to a second term as president of the Electronic Industries Assn. He is vice president, research and development, TRW Inc. Also re-elected was **J. A. Milling,** president of Sams Div., Howard W. Sams & Co., to a second term as association treasurer; and **James D. Secrest** as executive vice president.

Dr. N. F. Wikner: Appointed scientific assistant to the deputy director, scientific, of the Defense Atomic Support Agency (DASA). He was formerly a nuclear physicist with the General Atomic Div. of General Dynamics Corp.

Rex D. Lindsay: Elected a vice president of Memorex Corp. Also elected to a vice presidency was **Eugene L. Rogers.** Lindsay is director of manufacturing and Rogers, director of corporate planning.

John Campbell: Joined Rocket Research Corp. as director of contract administration. He was formerly with The Boeing Co.

F. Sydney Lodge: Elected a member of the board of directors and secretary of Signetics Corp. He is vice president-controller and treasurer of the corporation.

John R. Herring: Named vice president and general manager of the testing division of Wyle Laboratories. He was previously vice president/testing operations.

The Council of Defense and Space Industry Associations has named the following persons officers for the coming year: **Arthur P. Clow,** vice president of defense activities with Western Electric Co., as council chairman; **Fred C. Holder,** manager of special products division, American Motors Corp., council vice chairman.

Bernard S. Parmet: Appointed manager of engineering for Vitro Electronics. He was formerly with the Aero Space Div. of Hallicrafters Co.

—when and where—

AUGUST

Eighth Annual Space Technology Institute, sponsored by Air Force Systems Command, NASA and University of Connecticut, University of Connecticut, Storrs, Aug. 1-13.

Second Research Conference on Instrumentation Science, sponsored by Instrument Society of America, William Smith College, Geneva, N.Y., Aug. 2-6.

Eighth National Heat Transfer Conference, sponsored by American Society of Mechanical Engineers and American Institute of Chemical Engineers, Biltmore Hotel, Los Angeles, Aug. 8-11.

Tenth Technical Symposium, sponsored by Society of Photo-optical Instrumentation Engineers and Air Force Systems Command, Jack Tar Hotel, San Francisco, Aug. 16-20.

1965 National Meeting of the American Astronautical Society, Sheraton Palace, Aug. 18-20.

International Conference on Energetics, sponsored by ASME, University of Rochester, Rochester, N.Y., Aug. 18-20.

International Lunar Geological Field Conference sponsored by University of Oregon and New York Academy of Sciences, Bend, Ore., Aug. 22-28.

Cryogenic Engineering Conference sponsored by Cryogenic Society of America, Rice University, Houston, Aug. 23-26.

Conference on the Exploration of Mars and Venus, sponsored by Virginia Polytechnic Institute, NASA and Air Force Cambridge Research Laboratory, Blacksburg, Va., Aug. 23-27.

1965 Western Electronic Show and Convention (WESCON), San Francisco, Aug. 24-27.

1965 International Symposium on Antennas and Propagation, sponsored by Institute of Electrical and Electronics Engineers, Sheraton Park Hotel, Washingtin, D.C., Aug. 30-Sept. 1.

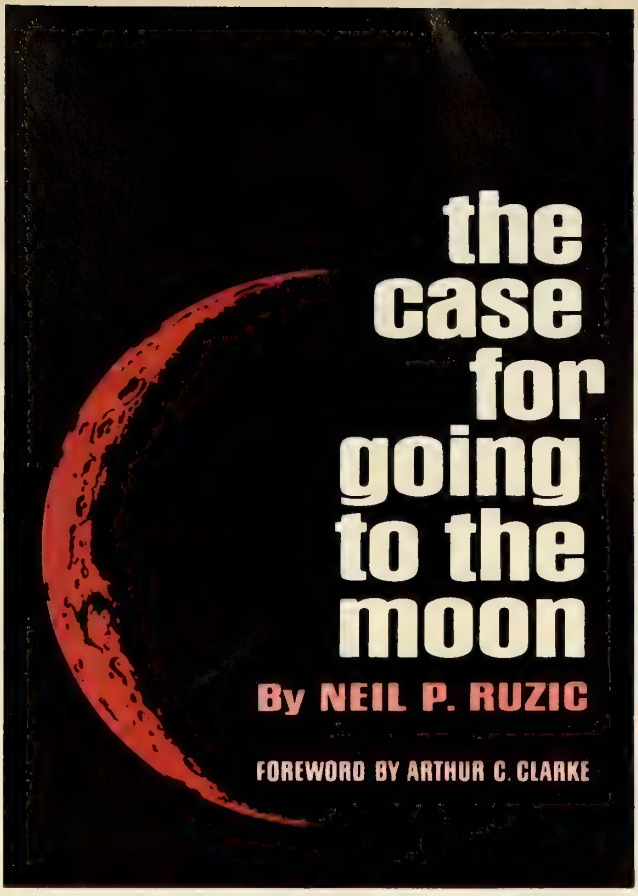
Twelfth National Conference of the Armed Forces Management Assn., Washington Hilton Hotel, Washington, D.C., Aug. 31-Sept. 2.

SEPTEMBER

Second Annual Conference on the Effects of Shock and Vibration on the Human Body, sponsored by University of Denver and the Colorado Chapter of the Institute of Environmental Sciences, University of Denver, Denver, Sept. 1-3.

URSI Symposium on Electromagnetic Wave Theory, sponsored by U.S. National Committee, International Scientific Radio Union (URSI), Technological University, Delft, The Netherlands, Sept. 6-11.

16th International Astronautical Congress, sponsored by the International Astronautical Federation, Athens, Greece, Sept. 12-18.



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Down to Earth

THERE IS MUCH OF INTEREST in the recent report by Governor Pat Brown on the preliminary results of California's effort to put the talents of the aerospace industry to work on several of that state's overwhelming social problems.

Aerojet-General has reported to the Governor that the systems engineering and advanced technology developed in the industry can indeed be put to work on waste management.

This is one of four areas covered by the feasibility contracts the state has let. The others are transportation, information handling, and delinquency and crime.

As one of the engineers put it to the Governor: "Compared with this project, *Mariner* was a snap." Nevertheless, Aerojet told Governor Brown that the systems management approach indeed is the only way to tackle such large-scale problems. The Governor plainly outlined why this is so when he said:

"Today, millions of dollars are being invested in research and development of a system for purifying the water in the Delaware River basin. At the same time, independent studies are being made over the nation on air pollution. The research is not connected, but the problems are. For example, an electrostatic precipitator traps all of the solid in industrial smoke. This cures air pollution. But if this solid waste is then dumped into a river or lake you have simply converted an air pollution problem into a water pollution problem."

As he pointed out, the only way to approach such a problem is from the systems management viewpoint. Waste management facilities will be built with or without the aerospace industry, but, Mr. Brown told a Congressional subcommittee, the difference is one of efficiency.

The funding on the present contracts is minor but the potential market for the industry is great. Aerojet's preliminary report estimates that with present methods California will be spending $1 billion annually by 1990 just to dispose of waste. By then, the report said, pollution of California's air, land and water will be causing about $7 billion in damage annually.

Anyone exposed to Los Angeles smog is all too familiar with the problem which must be overcome.

The Governor's effort to put the state's aerospace talents to work on these problems is an imaginative one. Other states and the Federal Government are watching the experiment with interest.

Mr. Brown has stated the reason he is seeking such help: "I wanted to know whether the scientists who gave us a clear look at the Moon could help us to sweep away enough smog to give us a clear look at our mountains as well."

Aerojet's work has given the Governor assurance that he is on the right track. Although these are just feasibility studies, Mr. Brown said that in the space of three years "a workable plan can be produced from which actual developments could begin."

These social problems are only one of the new areas to which the industry is turning as the potential of its systems engineering and advanced technology know-how opens new markets in addition to its defense and space responsibilities.

It is apparent that future growth for firms which grasp the significance of these developments is almost limitless.

LOCKHEED PRESIDENT Daniel J. Haughton analyzed this well in an address to the American Institute of Aeronautics and Astronautics in San Francisco last week. He said:

"It is easy enough to dismiss programs like these by saying that they are small ones. But we must not forget that the national space program was a small one only a few years ago. It was less than 10 years ago that space received significant funding—and only five years ago, in 1961, that President Kennedy established our national space goals. Today, by contrast, we are just formulating national water conversion and conservation goals. It is not inconceivable that in another five years water programs will be where our space program is today. Certainly they offer tremendous potential. Federally-supported water research is expected to double in these five years. Overall expenditures on water programs of all sorts at all levels, currently $15 billion a year, may double in 10 years.

As Mr. Haughton noted, water conversion and conservation is only one of a number of programs that may offer opportunities for the industry. Federal aid for urban mass transport has grown from $194,000 in 1964 to $48 million in Fiscal 1966. Federal support for transportation research has grown from $1 million in Fiscal 1964 to $122 million in Fiscal 1966.

"Ahead of us then," the Lockheed president said, "is a major challenge to meet demands in areas other than defense and space—demands that can only be met by an industry of high technology. Meeting these demands will take us into new fields of technology and new markets. We will have a whole new set of customers."

Mr. Haughton rightly pointed out that as important as space and defense are, they are not likely to absorb all of the industry's energies and talents. "I believe we will have enough left over to make positive contributions to the improvement of the nation's standard of living as well as the protection of it," he concluded.

It is encouraging to see the industry's capabilities put to work in these fields. Further results of the California experiment will be watched with interest.

William J. Coughlin

System engineering for airborne weapon systems

FIRE CONTROL SYSTEM FUNCTIONAL DESIGN

Responsibilities: The determination of detailed functional design requirements for complex Airborne Weapon Control Systems; system design per customer requirements; theoretical analysis of system performance and liaison assistance to engineering departments to develop equipment to fulfill system requirements.

Experience in one or more of these areas: **1.** System engineering involving missile or fire control systems. **2.** Field engineering on airborne systems. **3.** Test evaluation. **4.** Pulse doppler and other radar systems. **5.** Digital computer —airborne system. **6.** Inertial and microwave components. **7.** Circuit design, electrical power, armament control and IR subsystems, navigation and target tracking systems. **8.** Aircraft display and controls, human factors and electronic packaging.

Education: B.S. in E.E., M.E. or Physics. Applicants should be articulate in writing and communication as related to their responsibilities. U. S. citizenship required.

MISSILE SYSTEM FUNCTIONAL DESIGN

Responsibilities: Determine functional design requirements for advanced air-launched missiles; the design of such systems to meet customer requirements and theoretical analysis of system performance; coordinate and assist engineering departments in the development of equipment to fulfill the system requirements.

Experience: Two years minimum in one or more of the following fields: **1.** System engineering on missile or fire control systems. **2.** Field engineering on airborne fire control systems or missile systems. **3.** Test and evaluation of comparable systems. **4.** Radar systems (pulse doppler). **5.** Target tracking systems. **6.** Autopilot and control systems. **7.** Microwave systems. **8.** Digital computers. **9.** Navigation systems. **10.** Inertial components. **11.** Electrical power and armament control subsystems. **12.** Circuit design and electronic packaging.

Education: B.S. in E.E., M.E. or Physics. Articulate in communications. U.S. citizenship required.

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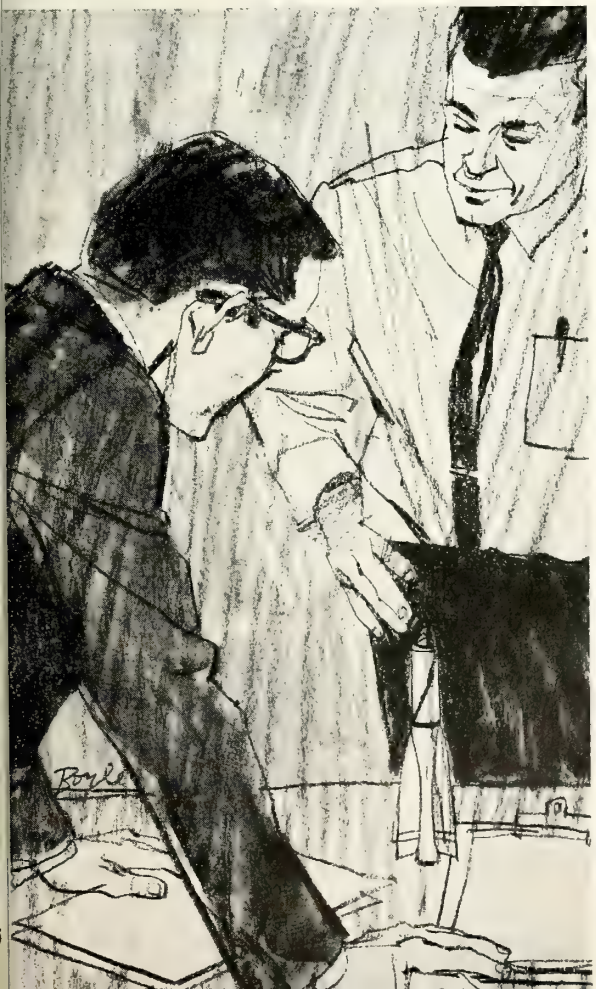


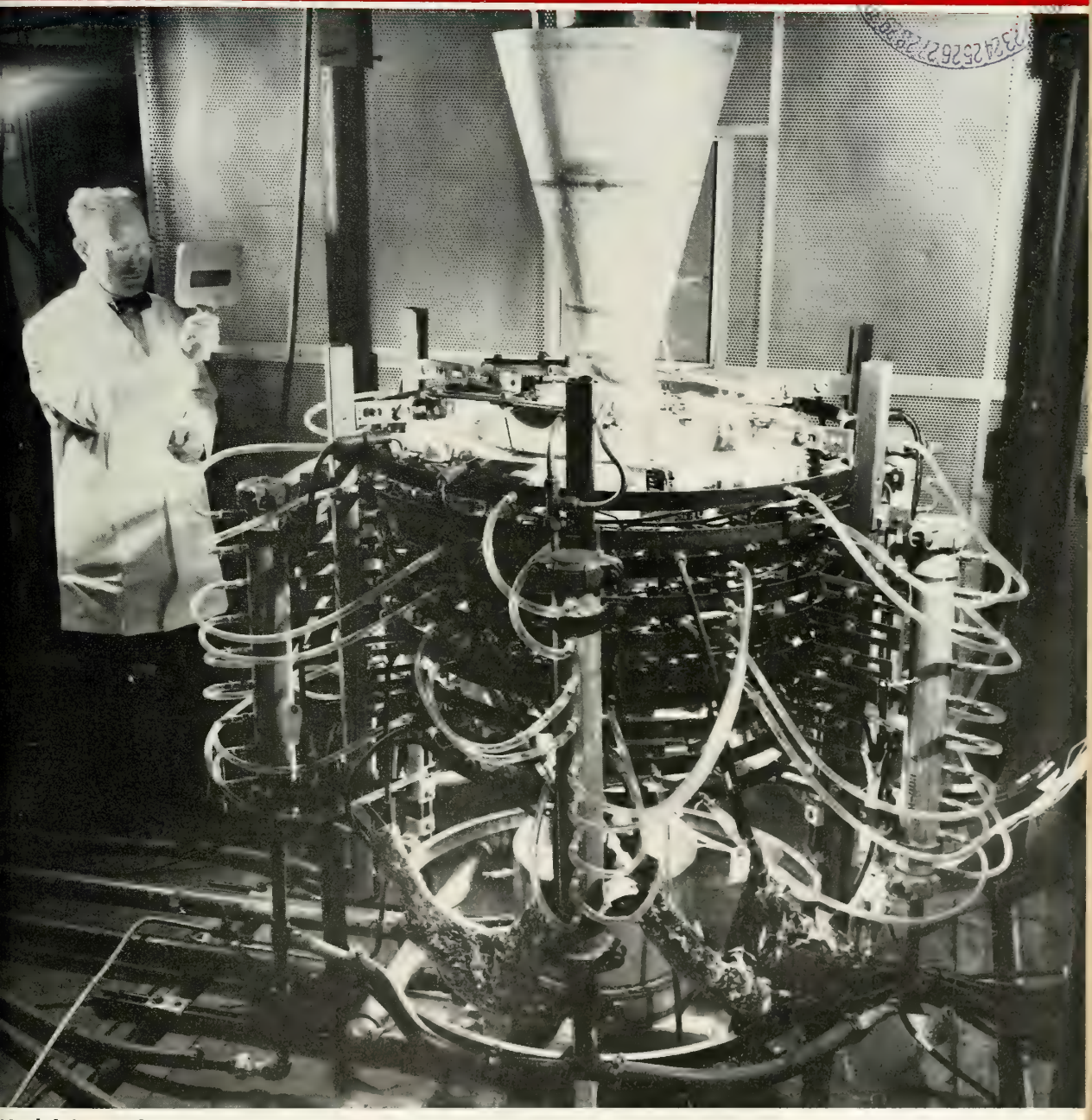
TRW SYSTEMS

Formerly TRW Space Technology Laboratories (STL)

AUGUST 9, 1965

missiles and rockets

THE WEEKLY OF ADVANCED TECHNOLOGY



Model in High-Temperature Testing at Boeing

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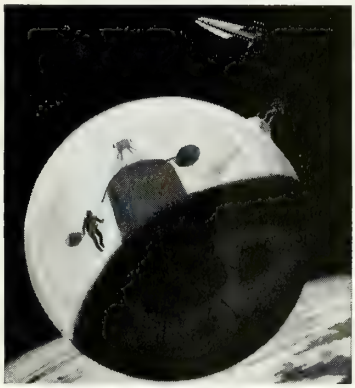
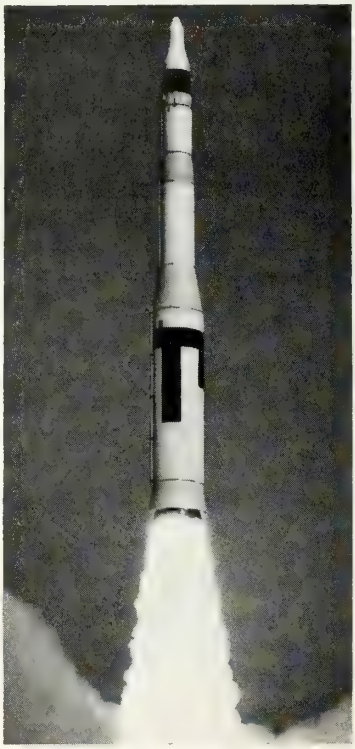
AN AMERICAN AVIATION PUBLICATION

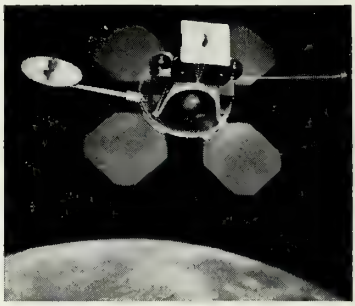
Space-Age Boeing Openings for Engineers and Scientists



Huge plastic cocoon could serve as space assembly "balloon," providing protection from solar radiation and temperature extremes. Proposal co-authored by Boeing bioastronautics scientist.



Advanced Minuteman II ICBM incorporates many improvements, including larger payload capacity, longer range, more sophisticated guidance system, increased accuracy.



First Lunar Orbiter flight, scheduled for next June, will seek out Apollo landing sites with sharp, detailed photographs of moon's surface. Boeing is building eight Orbiters for NASA.

The Boeing Company's deep involvement in the nation's most important missile and space programs is providing qualified engineers and scientists career opportunities of unusual scope and growth potential. Boeing currently is systems engineering and integration contractor for the NASA Saturn V launch vehicle, and is building the first-stage S-1C booster. It is also weapon system integrator for the U.S. Air Force's advanced Minuteman II ICBM, and prime contractor for the NASA Lunar Orbiter moon-scanning satellite.

Aero-Space Division assignments, listed in the right-hand column, are in research, design, development, manufacturing and test, and scientific and business computer technology. Requirements include a Bachelor's or advanced degree in an applicable discipline, plus related experience.

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Cryogenics
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Reliability
Service Engineering
Mechanical Design
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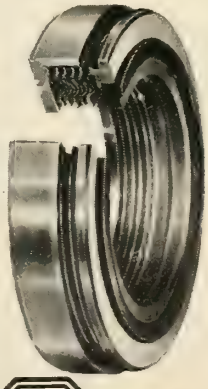

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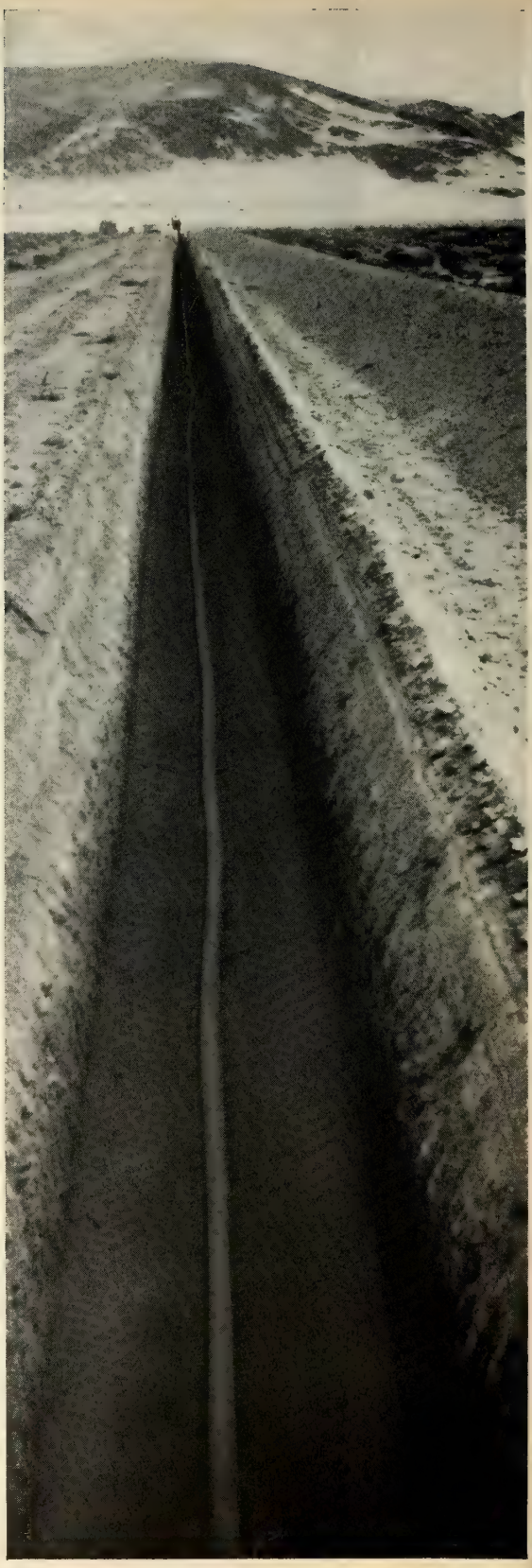

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Volume 17, Number 6 August 9, 1965

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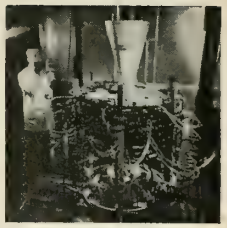

THE COVER

Model re-entry vehicle undergoing high-temperature testing at The Boeing Co. in Seattle. The cone is being positioned inside a facility capable of subjecting its surface to temperatures in the vicinity of 2,000°F. Water circulating within the cone dissipates heat in the form of superheated steam.

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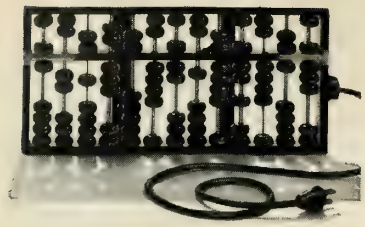

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OPTIMIZE commercial programs for efficiency and cost reduction and adapt programs to new equipment, certifying for conformance.

DEVELOP real-time data systems for commercial applications such as source data acquisition, updating, retrieval and administrative control systems.

ANALYZE and program new business applications on medium and large scale computers. Develop financial, engineering, manufacturing and procurement integrated systems for real-time and off-line functions.

PROGRAM and operate analog or hybrid computers and differential analyzers. Define models for simulation of aerospace guidance and control problems and analyze results.

Please write Mr. K. R. Kiddoo, Professional Placement Manager, Lockheed Missiles & Space Company, 530 Industrial Relations Building, P.O. Box 504, Sunnyvale, California.

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letters

Magnetic Suspension

To the Editor:

Apparently you have neglected to verify some of the information contained in the note on magnetic suspension and balance systems (M/R, July 19, p. 12). The last sentence of the second paragraph is misleading and undoubtedly would have been changed after deeper inquiry. Such inquiry would have disclosed that magnetic suspension and balance systems are in regular use both here at M.I.T. and at Princeton University. In addition to the places mentioned in the note, inquiry would have disclosed that successful magnetic suspension and balance systems have also been constructed and operated at the Von Karman Gas Dynamics Facility, the Air Force's Arnold Engineering Development Center, and at the University of Virginia.

Under Air Force sponsorship the M.I.T. balance has made possible the measurement of new aerodynamic data relating to static and dynamic stability, including damping-in-roll at many different angles of attack, over the last three years. Most of this data could not have been obtained with a conventional model suspension and balance system.

An analysis of available information indicates to us that the M.I.T. magnetic suspension and balance system is a more versatile wind tunnel instrument than those at O.N.E.R.A.

Eugene E. Covert, Sc. D.
Associate Director
Department of Aeronautics and Astronautics
Massachusetts Institute of Technology
Cambridge, Mass.

M/R did check on the information regarding the O.N.E.R.A. system—with both NASA and Air Force sources—and concluded that the magnetic suspension work there is on a larger scale than at any of the U.S. facilities mentioned.—Ed.

Nike-X Clarification

To the Editor:

After reading and re-reading the article on *Nike-X* in your Aug. 2 issue (p. 14), I can only conclude that portions of the text must be missing in a paragraph discussing the range and size of the *Zeus* missile. Is my impression correct?

Gene Lindberg
Science Editor
The Denver Post
Denver, Colo.

Your assumption is correct. Several lines were inadvertently dropped from the text. The paragraph to which you refer originally read: "Because of its operation in the sensible atmosphere, probably at altitudes in the 20 to 30-mi. range, there is a definite premium in limiting the size of the warhead of the rapid-acceleration Sprint missile. On the other hand, Zeus in its exo-atmospheric role can benefit from increases in warhead size within reason. Such Zeus increases would be desirable insofar as they involve no penalties in cost, missile acceleration or other performance." M/R regrets the omission.—Ed.

Ball One, Strike One

To the Editor:

I was not surprised to see the word "occulation" in "Mariner Nears 'Moment of Truth'" (M/R, July 12, p. 11).

It is a familiar word. In three articles that I have written on the subject of lunar occultations, I have had the letter dropped out by persistent editors.

From where do editors get this word? It is not in the dictionary. Perhaps you were thinking of "osculation" and expected to find Marsians (sic) thus engaged!

R. D. McAllister
Rossland, British Columbia
Canada

Ad Infinitum

To the Editor:

As the editor of an influential magazine which purports to be the leader among space weeklies, you have personally displayed a basic ignorance of one very important principle of leadership. You will not or cannot bring yourself to give praise for a job well done to the Jet Propulsion Laboratory.

In my estimation, the flight of *Mariner IV* was one of the greatest scientific and engineering achievements in the last 20 years. The people that made it possible deserve the highest praise. The President of the United States has given them praise. Radio, television and the press have given them praise, and *ad infinitum*.

You are the only holdout. Discounting any other asinine statements that could be the basis of other letters, I refer specifically to paragraph nine of your editorial "An Assessment" in the July 26 issue.

How you could interpret the first three pictures as "a ball of yarn" is beyond me. Perhaps you just wanted to say something bad about JPL, or it might be that you are in need of the services of an optometrist. Be that as it may, both Dr. Pickering and Dr. Leighton stated several times that the first three pictures were preliminary and that later pictures would improve as lighting conditions improved, terrain changed and the camera was brought nearer to the planet. I believe picture number eleven bears them out fully.

Therefore, your rash and impertinent statement, which was as scientific as a Salem witch hunt, should be retracted with haste, and a public apology made to the Jet Propulsion Laboratory.

Steven J. Zawacki
Alexandria, Va.

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If you have electronics equipment that must use precise 60-cycle power – and if light weight and mobility are important – you should talk to Garrett.

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Our static converters work well with standard piston engine generator sets – but when combined with Garrett-AiResearch 400-cycle gas turbine generator sets, they are the lightest weight and most compact dual frequency power sources available anywhere.

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Naturally. Navy's Deep Submergence Program requires in-depth experience in and under the sea. Sperry is a logical choice for navigation and control responsibilities in deep submergence. Sperry has been in the forefront in sea instrumentation and navigation throughout its history. Designer of the first gyrocompass, Sperry today is producing the advanced SINS (Ships Inertial Navigation System) for the new generation of attack submarines and surface vessels. Also, Sperry is navigation Subsystem Manager for both the U.S. and U.K. Polaris programs. Engineering skills here span from the latest microcircuit sonars to specialized computers and displays — and they include the skill for close integration in both equipment and systems.

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The Countdown

WASHINGTON

NASA Funds Set at $5.175 Billion

Final figure for NASA's Fiscal Year 1966 budget is $5.175 billion, as reported from a conference of House and Senate appropriations committee members. This represents a compromise exactly halfway between the House and Senate bills ($5.160 billion and $5.190 billion respectively) and is $85 million less than the agency requested.

Senate Seeks After-Apollo Testimony

The Senate Space Committee is trying to get witnesses together for a session on "post-*Apollo*" programs in space. Tentatively scheduled to appear during the fourth week of this month are Administrator James E. Webb, Associate Administrator Robert Seamans and Dr. George E. Mueller of NASA, and manned spaceflight officials from the Dept. of Defense.

Single Prime Likely for MOL

Most Air Force and DDR&E research experts believe that a single prime contractor will be chosen for development of the *Manned Orbiting Laboratory*. Doing this, rather than pairing two prime-contract candidates in a continuing run-off competition, would avoid a delay of perhaps six months in beginning full-scale development. *MOL* program officials at the design level say stretched-out studies have already provided such a detailed concept that there is virtually no need for further refinement of contractor proposals.

GSFC Shake-up Looming

A reorganization is in the works for the Goddard Space Flight Center, but has not yet been finally approved by top headquarters officials. It calls for providing more direct control over satellite and spacecraft projects. It will increase to six the number of assistant directors reporting to the center's top management. The main change takes away some of the responsibility of the office of the assistant director for space sciences with the creation of two new offices—the assistant director for technology and the assistant director for space sciences. In-house satellite projects will report to the technology office, with the big *Orbiting Solar Observatory* and other large spacecraft programs under the direction of the assistant director for projects.

AES Payload Assignment Expedited

NASA has decided to go directly to the program definition phase for the payload integration job for *Apollo Extension Systems* (*AES*). Previously, the agency planned to have a four-month study effort precede it. The RFP for a five to six-month program definition phase will be issued by the Manned Spacecraft Center in about four weeks. Two or three firms will be selected to do the job. Then the three will submit bids on how they would do the job and one will be selected as the prime contractor for payload integration. In the area of field center responsibility, NASA has also decided to split the work right down the middle between MSC and the Marshall Space Flight Center. This could mean that a second prime contractor will be needed later to handle the Marshall work.

Viet-Nam Logistics Streamlined

A special 10-man task force to expedite logistics for the war in South Viet Nam has been established by Defense Secretary Robert S. McNamara. The group will be headed by an Army brigadier general, reporting directly to McNamara, to keep him informed on an immediate, day-to-day basis about any shortages developing in military equipment dispatched to the combat zone. The group will travel to visit combat areas, fleet and field commanders and serve largely in a trouble-shooting capacity to expedite the movement of military supplies. Its action, short-circuiting regular logistics channels if necessary, will afford Pentagon top echelons an opportunity to correct isolated equipment bottlenecks promptly.

Gemini Landing System Passes Test

The third Earth landing (twelfth test drop) of the parasail/attenuation rockets landing system for *Gemini*-type spacecraft was termed "100% successful" by engineers at Manned Spacecraft Center. Dropped July 30 from a C-119 at 10,000 ft., the vehicle was turned into the wind, downwind and fully around several times by remote control before it was brought to a landing 40 ft. from the target. Last test in the series is planned for late September at Ft. Hood, Tex.

INDUSTRY

Three Firms Picked for ALSEP Designs

NASA has selected three companies to design the *Apollo* Lunar Surface Experiment Packages (ALSEP) under separate and concurrent $500,000, six-month, fixed-price contracts. They are Bendix Systems Div., Space-General Corp. and TRW Systems Group. The packages will contain scientific instruments to measure the Moon's structure and surface characteristics, atmosphere, heat flow, solar winds, radiation and micrometeorite impacts. Weighing less than 150 lbs. each, they will be carried to the Moon in the *Lunar Excursion Modules* on initial *Apollo* flights and placed on the surface by astronauts. Then they will transmit data for six months to a year. The three firms will deliver mockups of the package to Manned Spacecraft Center and Grumman Aircraft Engineering Corp., manufacturer of *LEM*, about March 1, 1966.

Backpack Life-Support System Delivered

Hamilton Standard, Windsor Locks, Conn., has delivered to Manned Spacecraft Center a prototype portable life support system (PLSS) weighing only 60 lbs. Worn beneath the lunar surface spacesuit (extravehicular mobility unit), the backpack cools and recirculates water running through plastic tubing in the astronaut's liquid-cooled underwear. The contract calls for delivery of 52 packs.

Space Goals Termed Peaceful

Misconceptions about the roles of DOD and NASA in the nation's space program cause unwarranted "friction between Government agencies, unnecessary suspicion of our intentions on the part of other nations, and serious difficulties for those who attempt to explain our space planning to the Congress and to the public."

This was the view expressed by Dr. Edward C. Welsh, executive secretary of the National Aeronautics and Space Council, last week in a speech before the Tenth Symposium on Space and Ballistic Missile Technology in San Diego.

Welsh deplored the growing tendency to equate NASA efforts with "peaceful" uses of space and all space efforts of DOD as somehow "non-peaceful." All of the nation's space activities and intentions are peaceful, he maintained.

But Welsh cautioned against misinterpretation of his remarks. "I do not mean, however, that we intend to be naive, complacent or weak," he said.

No arena within the reach of man is free from the possibility of being exploited by an aggressor. Moreover, no nation should bury itself in the hands of complacency and thereby neglect to develop the technological and military strength so necessary for deterring potential aggressors.

NAA Gets SINS Award

North American Aviation's Autonetics Div., Anaheim, Calif., has been awarded a Navy contract to study improvements to Ship's Inertial Navigation System (SINS) to adapt the submarine system to *Poseidon* missile requirements.

The three-part definition study will determine changes required in Autonetics' Mark 2 Mod 3 SINS. Under terms of the contract, the firm is to complete preliminary design and system integration studies, establish support requirements and determine required alterations by October.

Brazil To Aid in Studies

The Brazilian Space Commission (CNAE) will cooperate with space scientists from the U.S. and Argentina in a study of hemispheric weather patterns.

Brazil will launch a series of meteorological sounding rockets this year as part of the inter-American Experimental Meteorological Sounding Rocket Network. The network will launch rockets on a coordinated basis from a chain of stations through the western hemisphere.

Brazil will transport rockets and equipment from the U.S. to Brazil, assemble and launch the rockets and provide the meteorological data to other participants in the network. NASA will lend ground support and train Brazilian personnel. First launchings are scheduled before the end of the year from Natal, Brazil, and Wallops Island, Va.

Up-Rated Scout Readied

A new version of the *Scout* booster with an increased payload capability of 305 lbs. is scheduled for launch Aug. 10 from Wallops Island, Va.

The first in the improved *Scout* series is called a Systems Evaluation Vehicle; primary objective of the launch is to evaluate performance of new systems and components. The booster will be heavily instrumented and carry a number of special measuring devices. Secondary objective is the launch of a 44-lb. Army *SECOR* geodetic satellite. If the launch is successful, the satellite will be placed in an orbit ranging from 700 to 1,700 statute miles. Orbital time will be about 126 minutes.

Soviets Release New Missile Launch Photo

RUSSIAN Communist news sources last week distributed this photograph of a naval vessel firing a reportedly new type of missile. They did not describe the weapon, except to say that it was "capable" of delivering a nuclear warhead.

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A career with General Dynamics | Convair is enhanced by the opportunity to live in San Diego . . . one of the country's foremost vacationlands. It's an ideal family city with a pleasant year 'round climate and superb recreational facilities. And its institutions of higher education and research centers have endowed the community with a most desirable academic atmosphere.

INFORMATION SYSTEMS

BS, MS and PhD's in EE, AE, Physics and Applied Math required with related experience in large-scale digital computer simulations. Assignments will be in:

1. The application of GEMBET (Generalized Error Model Best Estimate of Trajectory) for reducing tracking and guidance data to evaluate the tracking and guidance systems as well as determining the vehicles' trajectory.
2. The application of VESS (Vectran Engineering Simulation System) to trajectory and error analysis problems.

Other openings exist in the Apollo Instrumentation Ships Program and in basic research on Information Systems.

THERMODYNAMICS

BS or MS in ME or AE and 2-5 years' applicable experience required, to develop analytical techniques, perform theoretical studies and conduct experimental programs related to the following areas:

1. Long-term cryogenic storage including insulation systems, cryogenic stratification, tank pressurization and venting, and propellant behavior during boost and low-gravity conditions.
2. Boost and entry heating and vehicle heat protection systems, including real gas effects, reaction kinetics, flow fields and ablation phenomena.
3. Temperature control of vehicle systems and subsystems exposed to the environments of space, including thermal isolation and heat sinking effects.

STRESS ANALYSIS

Specialists are required to perform stress analysis on advanced missile and space vehicle designs and associated ground equipment. Additional tasks in this area are the development of new analysis methods and the testing of vehicles and components for evaluation of structural adequacy.

BS or MS degrees and at least 3 years' appropriate experience are prerequisite for these positions.

GUIDANCE ANALYSIS

Advanced Guidance

PhD EE, Physics or Applied Math required to:

a. Apply the technique of optimal control theory and statistical filtering to the development of nonlinear and adaptive navigation and guidance software concepts. Applicant should be familiar with the application of Pontryagin and Liapunov functions and other calculus of variations techniques. He should be able to apply statistical or Kalman filtering techniques.

b. Investigate and evaluate proposed guidance systems and define their applicability to aerospace vehicles within the framework of vehicle design and mission objectives.

Guidance Software

BS or MS EE, Physics or Applied Math, with 2 years' experience minimum required to: Analyze and synthesize guidance techniques and systems for military and space vehicles, from conception to detailed formulation. This work includes the formulation of the basic guidance concept, the development of guidance equations, the definition of required measurement accuracies and the demonstration of system performance by means of digital and/or analog simulation.

This work is directed toward the guidance of vehicles in planetary orbits, re-entering planetary atmospheres, and performing lunar and interplanetary operations. Radio, optical, inertial and hybrid guidance systems, and the required mathematical treatment of the measured data are considered in these analyses.

PROGRAMMING

Engineering and Scientific Programmers

Positions are available for engineering and scientific programmers with a minimum of a BS degree and 2 years' experience in symbolic programming for large-scale digital computers. Assignments will involve engineering and scientific programming applications. The tasks include real-time program organization, multi-channel input/output for peripheral equipment, utility and diagnostic routines, data simulation, and programs for analysis and synthesis of the tracking and navigation data. Equipment utilized is an IBM 7094-44 directly coupled system.

Business Programmers

Positions are available for programmers with two years' experience on 7074 and/or 7010 equipment. Preference given to programmers familiar with COBAL, although this is not a prerequisite.

GUIDANCE SYSTEMS

BS or MS with strong electronics and math background for detailed error analysis on Inertial Guidance Systems and associated checkout and calibration techniques. BS or MS in EE with 2-5 years' experience for Guidance System integration. Will work with guidance contractors at all levels and support both conceptual and detailed design review and analysis. Other assignments include detailed systems definition for computer-controlled guidance, auto-pilot, and vehicle checkout systems. Definitions must be detailed to allow straightforward reduction to machine language. Knowledge of compilers, languages, philosophy of program structure, and real-time applications of computers is required. Electronics background desirable.

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According to officials at LTV Aerospace Corp., systems manager for the four-stage rocket, the uprated *Scout* incorporates several engineering improvements. These include two higher-performance motors for the second and fourth stages, to provide new maneuvering capability, and improved spin motors to stabilize the fourth stage and payload during injection in orbit. The new *Scout* can place 305 lbs. in a circular 300-mi. orbit—an increase of nearly 80 lbs. In a high-altitude probe launch, the booster can loft a 100-lb. payload 11,200 mi. Previous *Scout* rockets could launch the same weight only 7,000 mi.

Moon Drill Pact Awarded

Marshall Space Flight Center has awarded more than $1 million in contracts for development of a drill to probe below the Moon's surface.

Northrop Space Laboratories received a $509,992 contract and Westinghouse Electric Corp.'s Defense and Space Center was awarded a $570,624 contract for parallel 1-year feasibility studies. The tool will be used by astronauts on post-*Apollo* missions. General requirements for the system will be a capability of drilling and taking cores 100 ft. below the lunar surface. Unit weight will be less than 200 lbs.

Northrop and Westinghouse will manufacture engineering models as the system is developed. The equipment will be a facsimile of the final version and tested under simulated Moon surface conditions.

New Spy Satellites Weighed

Launch system and payload requirements for a new multi-function successor to the *Midas* and *Samos* surveillance satellites will be compiled by September as a result of 4-month studies presently under way in industry.

Phase I studies in the program, designated P147, are being conducted by three groups: Lockheed Missiles & Space Co., teamed with Baird/Atomics; TRW Systems Group, teamed with Aerojet-General Corp.; and Hughes Aircraft Co.'s Santa Barbara Research Center.

Hughes has reportedly awarded a funded study to the Martin Co. to define the booster problem and accompanying launch characteristics. Objectives of the studies include investigation of the feasibility of designing such a satellite for synchronous orbit on the basis of presently available technology, along with consideration of design of a satellite of lesser complexity for an orbit of about 7,000 mi. altitude.

Sensors along with attitude-control and stabilization techniques appear to be considered the critical factors in satellite design—particularly in design for a synchronous orbit.

AF Admits Contracting Flaws

Apprehension that Air Force and other DOD contracting agencies may be overly insistent on detailed cost data and too much design detail—and otherwise imposing too many complexities in asking industry to submit incentive fixed-price proposals—were voiced by Air Force installations and logistics secretary Robert H. Charles last week.

Addressing the second annual American Institute of Aeronautics and Astronautics session in San Francisco, Charles suggested that a better approach might be for the Air Force to specify its requirements in terms of performance, then permit the winning competitor to achieve that performance in his own way.

Charles expressed concern over the fact that minute details now insisted upon during the contract definition phase of a program inevitably mean increased expense. "Someone has to pay for it," Charles said. "The Air Force tries to pick up the tab . . . but the plain truth is that the companies in the competition, knowing how important it is to win, spend much more than we provide them. A second problem is the length of time it takes us to pick a winner after all proposals are in. During this period the competitors are holding their teams together, again at great cost, and this serves an immediately useful purpose only for the ultimate winner."

The Air Force official noted that the "total package" approach to defense contracting has shown such promise that it will be applied to *SRAM* development and procurement and also to the *Mark 17* re-entry vehicle. Among other items, the total package approach sees procurement in terms of the total development cost and operational life of a military hardware system, without necessarily being much concerned with its breakdown for each fiscal year in terms of cost, functions and components.

Texas To Get S-Band Gear

NASA plans to install equipment for the Unified S-Band System for use with the *Apollo* space flights at its Corpus Christi, Tex., station.

With the system, the station will be able to combine in a single two-way transmission all types of com-

munications with the three *Apollo* astronauts. NASA will construct a 30-ft.-dia. parabolic antenna, the same type of equipment to be installed at Cape Kennedy, Bermuda, Ascension Island, Carnarvon, Guam and Guaymas stations.

Seven kinds of communications will be conducted simultaneously for *Apollo*. These include tracking the spacecraft, commanding its operations and confirming execution of commands, two-way voice conversation, continuous check on the spacecraft, continuous information from on-board experiments and television pictures of the astronauts and their exploration of the Moon. All communication will be conducted with the one ground antenna.

Shots of the Week

The Air Force launched a *Minuteman II* ICBM from Cape Kennedy on Aug. 4. Preliminary range data showed that the instrumented mock warhead impacted on target.

S-4 Explosion Yield Encouraging

NASA and Air Force engineers are reported to have been "pleased with the extremely low blast yield" of a fully fueled *Saturn* S-4 stage intentionally exploded at Edwards AFB, Calif.

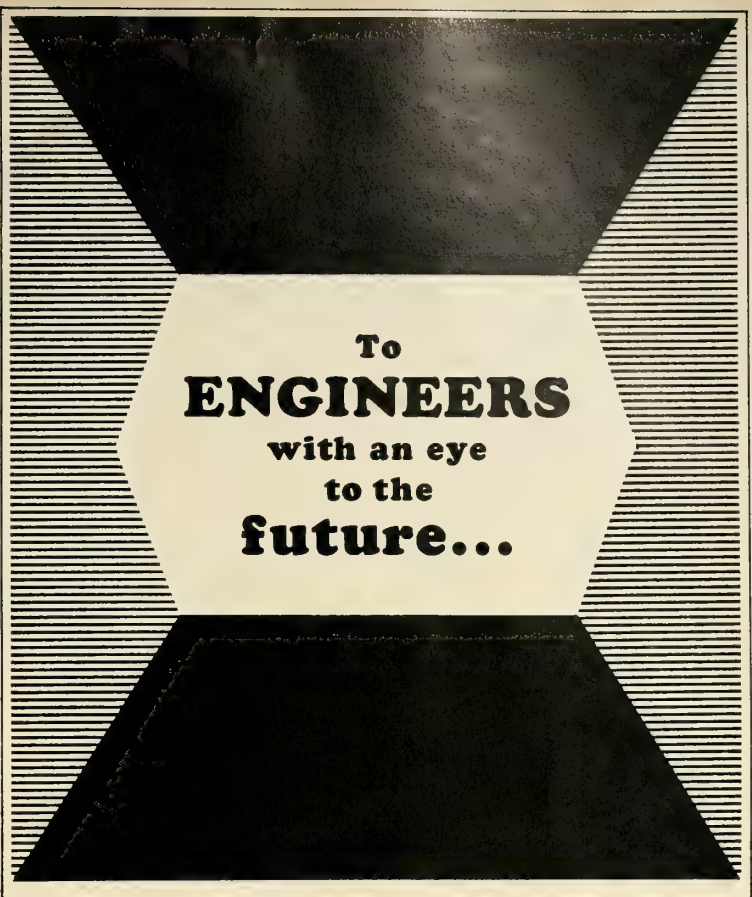
The blast yielded the equivalent of only 9,000 lbs. of TNT. If the full energy of the stage's 7,800 gallons of liquid oxygen and 28,000 gallons of liquid hydrogen had been released, it is calculated that the yield could have reached 90,000 lbs. of TNT.

To explode the S-4, a long harpoon charged with shot-gun powder was fired through the bulkhead separating the propellant tanks. As the stage disintegrated, high-speed cameras and instruments recorded radiation and shock intensity.

NASA Hosts Biologists

A training program for biologists interested in gaining experience in the operational and engineering aspects of space flight begins this week at Wallops Island, Va.

Some 32 professional biologists are attending the Bio-Space Technological Training Program, sponsored by NASA and the University of Virginia. The scientists will study the biotechnological aspects of spaceflight and spacecraft design. During the institute, four modified *Arcas* sounding rockets will be used to loft white rats 20 miles into the atmosphere in a demonstration of biological experimentation techniques.



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Powerplant Performance Analysis—conduct current and advanced performance studies, perform system analysis, evaluate test data to provide a criteria for recommending programs to improve efficiency and dependability of powerplants and components under development.

Electromechanical Instrumentation—acquisition of fluid flow, stress, vibration and acoustics data during steady state and transient operation of a variety of energy conversion devices.

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AES Experiments May Cost $700 Million

Four-year program might begin in 1968; sixteen flights foreseen; official details wide range of projects involving all centers

NASA IS PREPARING PLANS for a manned experimental program for the *Apollo Extension Systems (AES)* which could cost, if approved by the Administration and Congress, an estimated $700 million.

A NASA official told MISSILES AND ROCKETS that "we have progressed to the point where we have pulled the experiments into one package and we are looking at them to see if they will hold together. We have already verbally briefed top management people at both Headquarters and key field centers."

Details of the program are expected to be officially transmitted to the field centers involved in a week to two weeks.

NASA currently envisions a four-year program which could begin as early as 1968. Sixteen flights of *AES* are currently planned with the modified *Apollo* Command and Service modules and the lunar extension system. The LEM will also be modified for 14-day lunar surface operations and lunar orbit missions of up to 28 days.

• **Breakdown**—The current plan calls for breaking the experimental program down into 15 major areas: astronomy and astrophysics; physical sciences; advanced technology and supporting research; extravehicular engineering activities; communications and navigation/traffic control; biomedicine/behavior; behavior; operations techniques and advanced mission spacecraft subsystems; atmospheric science and technology; Earth sciences and resources including agriculture/forestry, geology/hydrology, oceanography/marine technology and geography; and bioscience.

The NASA official said that in the biomedicine/behavior area, some of the scientific physiological experiments could include carotid baroreceptor reflexes, pulmonary function, ventilatory gas exchange, gastrointestinal motility and pH, human neuro-endocrine function and hemostasis. In the development of standards applicable to space medicine, experiments may cover thermal regulation in man and determination of his work capability.

In the field of operations techniques and spacecraft subsystems, planned experiments include evaluation of the advanced spacesuit assemblies, personal hygiene, and use of on-board centrifuge for providing artificial gravity. In development of advanced operations techniques, experiments would include emergency techniques for rescue operations and orbital maneuvering and docking.

In bioscientific investigations, the NASA official said, experiments could cover environmentally induced changes in biological material. This will include study of genetic effects in microorganisms, effects of space on unicell organisms and animal tissue, and limb regeneration and wound healing.

• **Weightlessness study**—Experiments could also test physiological responses to weightlessness in animals. This is planned to cover effects of weightlessness on primates, effects of drugs on mammalian behavior and otolith function in frogs.

Experiments are also planned to study the collection and survivability of microorganisms in near-Earth space.

The official commented that experiments would include measurement of the environment utilizing such techniques as radiation environment monitoring, analysis of comet-like particulate clouds, cosmic ray emulsion and study of magnetic field lines.

• **EVA stressed**—In the area of extravehicular engineering, plans call for various manned assembly and test of structures, such as studying the effects of space environment on structures, orbital testing of a large solar cell array, and extravehicular assembly operations.

In order to develop a capability for manned extravehicular manipulations, the official said, there will be experiments in optical technology, development of manned locomotion and maneuvering, and launch of an unmanned satellite.

Finally, there will be studies on procedures for transfer, launch and recovery, including personnel and cargo transfer operations, propellant handling techniques and an attempt to recapture *Syncom III*.

• **New mapping**—In the area of astronomy and astrophysics, the official indicated there would be investigation into the existence and features of extraterrestrial life, surface mapping, morphology, composition and internal mechanisms of astronomical bodies. This would be accomplished through various experiments with an intermediate-size reflecting telescope, radio astronomy, X-ray astronomy and a manned solar observatory.

The experimental package program for *AES* was pulled together by a group of NASA officials at various field centers and Headquarters. Heading the group were Edward Z. Gray, director of the advanced manned missions program in the Office of Manned Spaceflight, and Maurice J. Raffensberger, director of manned Earth-orbital missions studies.

The various experiments will not receive final approval until the liaison activities and discussions with the field centers involved are concluded.

• **Wide participation**—Although no final decision has been made, the official said, almost every NASA field center will have management responsibility for some part of the experimental program. The current philosophy, he said, would break down Earth-orbit activities with six field centers sharing the program.

This probably would mean that the Manned Spacecraft Center would be responsible for biomedical experiments and operation techniques and advanced mission spacecraft subsystems. Marshall Space Flight Center, because of its developmental work in extravehicular systems, probably would direct this area of activity. Bioscence work probably would go to Ames Research Center because of its pioneer work in the field. Goddard Space Flight Center, because of its previous experience, is likely to direct astronomy, physical sciences and atmospheric work. Other centers expected to be involved include the Electronic Research Center and Langley Research Center. In the lunar surface and lunar orbit areas, centers likely to be involved include MSFC, ERC, Goddard and Jet Propulsion Laboratory. ■

Senate Fears DOD Fund Reprogramming

Stennis urges 'more realistic' detailing of Vietnamese requirements; MOL seen safe from any reshuffling of money

SENATE LEADERS of the Armed Services and Appropriations committees, which have been asked to give the Dept. of Defense $1.7 billion in extra Fiscal Year 1966 funds to support the Viet-Nam situation, are pressing for "more realistic" figures on what DOD needs in the next few months. They want to supply the necessary funds now so that other critical programs will not be stretched out as DOD finds itself short.

Sen. John Stennis (D-Miss.), who has been acting chairman of the Senate Armed Services and Defense appropriations subcommittee, said late last week that the committee had not heard yet of any intentions to reprogram funds from other sources, such as research and development, as has been hinted around the Pentagon. However, Stennis emphasized that the committee wants to avoid such actions by getting definite figures now on Viet-Nam costs.

Although some published reports have indicated that the *Manned Orbiting Laboratory* may be a target of DOD money shufflers, Stennis said that such action is virtually impossible since the language in the authorization bill already passed by the Congress and signed by the President specifically says that the $150 million in FY 1966 funds authorized for *MOL* may not be used for any other purpose. He said he found it hard to believe, as the same published report had it, that money would be diverted from the *Minuteman II* program. A top DOD source confirmed the unlikelihood of *MOL* being affected.

• **Amendment**—What Secretary Robert S. McNamara is asking for from the Congress is that an additional $1.7 billion be tacked on the Defense appropriations bill now before the Senate, and that the ordinary authorization process for this money be waived for expediency's sake, in much the same manner as the $700-million supplemental for the previous fiscal year was handled.

Stennis said the $1.7 billion is not enough to cover the costs already accrued beyond available funds, although he added that he would of course support the bill. The additional money is being requested for ammunition and other supplies, characterized as "long leadtime" items by Stennis.

None of this money goes toward support of the 340,000 additional troops which McNamara has said will be added to the nation's forces. To provide this additional strength, the Secretary said, the current draft call rate of about 17,000 per month will be approximately doubled. To cover salaries and personnel costs for these troops, McNamara also asked emergency authority to spend money not appropriated. This clause has been in DOD bills in the last few years, and allows the Secretary to take such an action if additional forces are found necessary during the year.

In a Senate speech before the Secretary's appearance, Stennis reported that the Preparedness Subcommittee of the Armed Services Committee has completed a classified report which finds that the Army has significant and existing problems in equipment shortages, lack of repair parts and a substantial amount of overage equipment, particularly in the wheeled and tracked area.

• **More to come**—In making his presentation to the committees, McNamara made it clear that this is by no means the last such action contemplated in this fiscal year. The request is "pending the submission of a detailed FY 1966 supplemental request to the Congress when it convenes in January." He added that manpower needs will "undoubtedly" increase in the future.

By next January, McNamara said, DOD will be in a much better position to state additional requirements for the balance of the fiscal year. However, the $1.7-billion amendment will provide financing necessary to "gear up the production machine—to accelerate the delivery of essential items already in production and to initiate the production of new items required for the support of our forces in Southeast Asia, as well as the construction of the most urgently needed facilities." It will go, he indicated, to replacement of ordnance and ammunition—war-consumable stocks, aircraft to replace those being lost, and additional helicopters for the new Army and Marine aviation units soon to be activated. ■

ARPA To Use Redstones in A-ICBM Work

A SMALL NUMBER of *Redstone* missiles formerly deployed with the U.S. Seventh Army in Europe will be recalled to duty in connection with an Advanced Research Projects Agency (ARPA) classified program. Defense officials have indicated that the total number of *Redstones* that can be refurbished and made ready for firing is "less than 30."

ARPA awarded a $1.3-million contract in June to Chrysler's Missiles and Space Division, Warren, Mich., to recondition an unspecified number of the IRBM's.

All *Redstones* deployed in Europe were returned to the United States in a gradual phase-out completed last summer and were replaced overseas by mobile *Pershing* missile batteries. Those judged suitable for reconditioning have all been forwarded to Chrysler's Warren facilities.

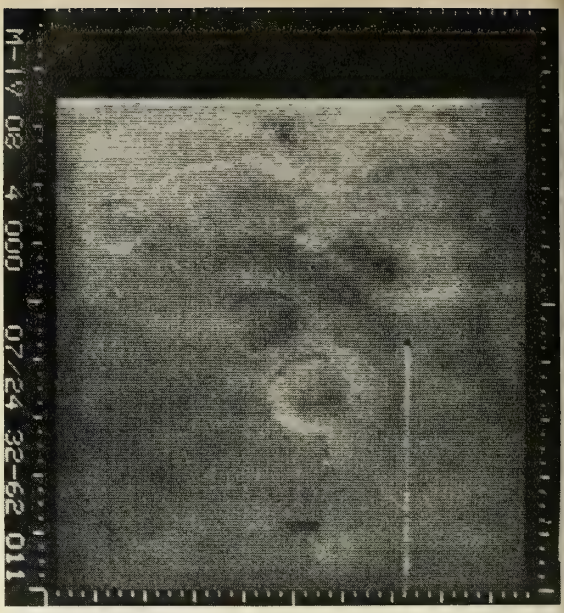
While the ARPA contract covers only refurbishing of the *Redstones* that agency will use for two different programs, one of them still tentative, the Army also is considering use of some of these missiles.

• **A-ICBM plans**—A number of the reconditioned missiles will be used by ARPA in "a cooperative program with Navy, relating to ballistic missile defense measurements." A second group of *Redstones* will be "held in reserve, pending the outcome of discussions now under way with the Australians and the British for a cooperative series of experiments" also associated with ballistic missile defense measurements.

Defense sources indicated that ARPA will not be using all of the available *Redstones*. Although plans are not final, Army's Missile Command is considering using some as target vehicles in connection with its program for increasing the capability of its *Hawk* surface-to-air field defense missile. FY 1965 funds totaling $44.6 million and an additional $9.4 million requested in FY 1966 are earmarked for improvements to *Hawk*, including providing the system with new anti-missile missile capability.

Mariner Photos To Be Studied with Eye to Voyager

First examination of pictures indicates no need to change design of planetary lander



EIGHTH MARINER picture, taken at 8,300-mi. slant range, shows border between Zephyria and Mars Sirenum. East-west area covered is 180 mi., north-south 170 mi. Sun is 32° from the zenith from North in the photo. Location is 16° south latitude, 187° east longitude.

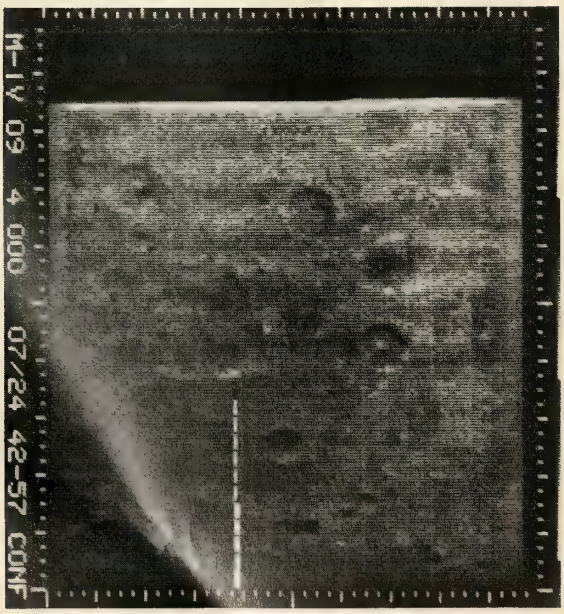
NASA OFFICIALS REPORT that it probably will be several months before evaluation of *Mariner IV* data is completed and a determination made as to whether the results will force changes in the design of the *Voyager* spacecraft.

A spokesman said that no changes were indicated in the early look at the data, but this could change when the final analysis by the spacecraft experimenters is received by the space agency.

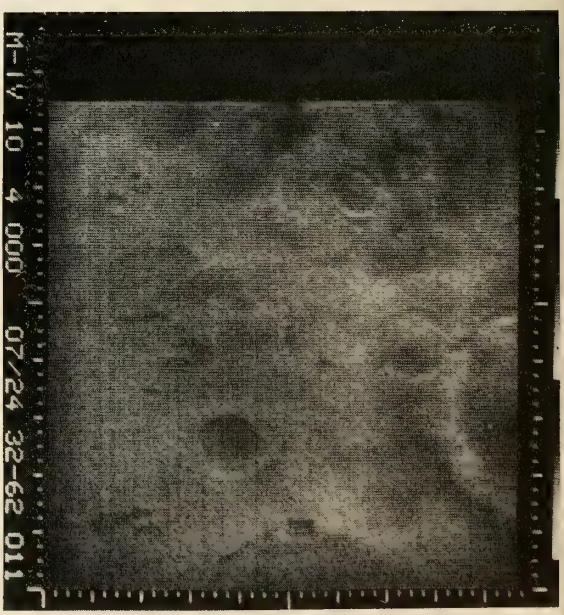
The official's comments were made as NASA reported officially that Mars' surface is far more like the Moon than Earth, that the one percent of Mars photographed by *Mariner* is pockmarked by craters, and that there are indications of frost on the planet.

He also said that the 21 pictures transmitted back to Earth gave no indication of life on the surface. They also pointed out that of the thousands of *Tiros* weather pictures which have been taken of Earth, only one has ever

MARE SIRENUM, bordering on Atlantis in southwest corner of frame, is principal feature of Picture #9. Sun here is 38° from zenith, slant range is 8,100 mi. East-west area shown is 170 mi., north-south is 160 mi. Location is 23° south latitude, 191° east longitude.



PICTURE #10 shows Atlantis, bordering on Mare Sirenum in northeast corner of frame. Sun is 41° from the zenith and slant range is 8,000 mi. Area covered is still 170 mi. east-west and 160 mi. north-south. Location is 26° south latitude, 192° east longitude.



shown any indications of life.

They also declared that the photos were not expected to detect life and NASA had never expected them to.

● **Craters surprise**—The experimenters, Prof. Robert B. Leighton and Prof. Bruce C. Murray, both of the California Institute of Technology, were quick to admit that they were surprised by the presence of craters on the Martian surface.

"I think the fact that Mars is densely coated with craters—and I think that's a fair extrapolation to make because the chance of our happening to have seen the only place that has craters on it when we have a one percent chance of hitting it is really very small—coupled with the fact that these craters must by our experience with the Moon be extremely old—is the great surprise to me, at least," Leighton said.

The existence of the craters, the officials said, indicated that Mars was 2-5 billion years old.

The cratered area, including one depression with a diameter of 75 mi., is very comparable to the surface of the Moon.

Measurements of the Mars craters showed the slopes to be reasonably gentle, with the steepest one only ten degrees. This indicated weathering of the surface of Mars, but this was expected because Mars does have an atmosphere and dust clouds have been photographed by land-based telescopes.

Murray said that as far as what the composition of the surface is concerned "I think we probably would answer the question by saying: what are the differences between the Moon and Mars? And the differences would probably be associated with the presence of an atmosphere that blows loose dust, not necessarily some superfine crust. The slopes do seem to be a little bit gentler; if this is true after careful analysis and careful comparison, we would infer it may be somewhat smoother and more rounded off.

"But this is highly preliminary, and there are many other factors that have to be looked at carefully from other sources of information before I think anybody would really run out much neck on that particular question.

"There is known to be loose dust on Mars from ground-based observations. We see dust storms. The Moon has been inferred to have some kind of sticky dust perhaps under those conditions."

● **Voyager no sweat**—James E. Webb, NASA Administrator, denied that the low surface pressure—estimated to be 10 to 20 millibars—would drastically affect the *Voyager* program.

"I think you could say that our view is that this flight revealed nothing that would indicate we could not land there, that there is no negative information here that would seem to indicate difficulty or an impossibility that we have not contemplated before," he declared.

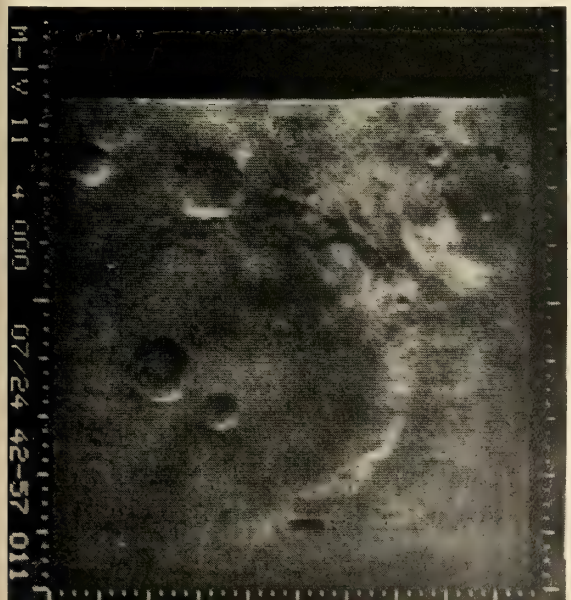
He and Dr. William Pickering, director of the Jet Propulsion Laboratory, also denied that NASA would use the backup *Mariner* spacecraft for another flight to Mars in 1966.

NASA said that it will issue no further status reports on the *Mariner IV* now that the transmission of its photos has been completed.

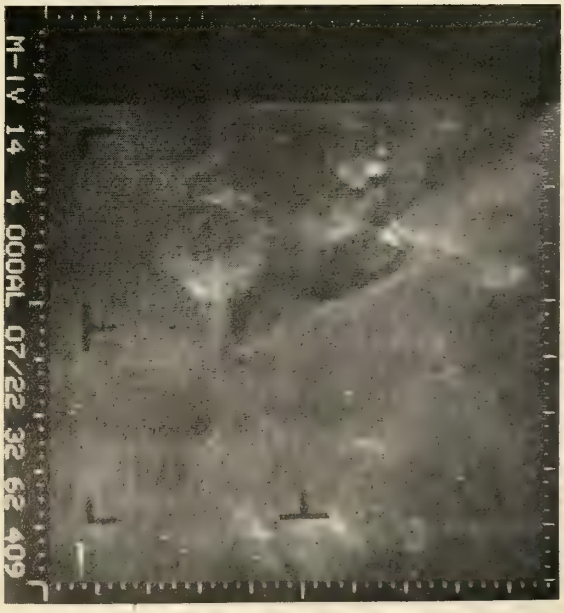
● **More from Mariner**—After the end of second playback of the *Mariner IV* pictures, at about 8:40 p.m. EDT Aug. 1, JPL sent a series of commands to turn off the tape recorder and return to cruise-mode science and engineering telemetry. The 100 kw S-band transmitter at the Venus site of Goldstone Deep Space Instrumentation Facility was used to relay the series of commands to the spacecraft. About 6-8 weeks' more data from scientific instruments on *Mariner* is expected following this move.

After that time *Mariner's* directional antenna will no longer be pointing towards Earth. A command will be sent to switch the spacecraft's transmitter to the omni antenna. Subsequently, monthly checks will be made to detect the infinitesimal energy reaching Earth from the spacecraft. No telemetry or Doppler tracking data is expected, just an indication that the spacecraft is still operating. ■

ATLANTIS, between Mare Sirenum and Mare Cimmerium, appears again in Picture #11. Sun is 47° from zenith, slant range is 7,800 mi. Coverage now is 170 mi. east-west and 150 mi. north-south. Location is 31° south latitude, 197° east longitude.



PICTURE #14 shows bright region of northwestern Phaethontis. Slant range is 7,600 mi., Sun is 60° from zenith. East-west coverage remains 170 mi. but north-south area has shrunk to 140 mi. Location of area is 41° south latitude and 208° east longitude.



Slippage Possible in GT-5 Launching

Problems with cryogenic storage and crew training indicate Aug. 19 target may be unrealistic; MSC outlines flight plan

NEW TECHNICAL PROBLEMS may force some slippage in the launch schedule for the *Gemini 5* mission.

NASA officials said that, while the schedule is tight, the launch target date remains the originally slated Aug. 19.

They admitted, however, that engineers are finding it difficult to maintain an eight-day supply of cryogenics in fuel cell storage bottles. The bottles hold 180 lbs. of liquid oxygen and 22 lbs. of liquid hydrogen in the spacecraft adapter, but are heating up more rapidly than expected and "boiling off" the chemicals into gases. Topping off the bottles may maintain the mission supply through the pre-launch countdown, but engineers feel that extra insulation may be required.

Also making the launch date tight, according to MSC, is the need for additional crew training and time to resolve launch pad erector problems.

The *Gemini-Titan* Aug. 19 schedule calls for a 9:00 a.m. (EST) liftoff. The booster is to be launched on a 72-degree heading, injecting the two-man spacecraft into an 87-187 n. mi. orbit inclined 32.5 degrees at the equator.

● **Rendezvous drill**—Howard W. Tindall, Jr., of the Mission Planning and Analysis Division at NASA's Manned Spacecraft Center, Houston, Tex., detailed the rendezvous portion of the flight plan:

The crew will check out spacecraft systems during most of the first orbit while ground tracking determines spacecraft orbital parameters.

Over Carnarvon, Australia, Command Pilot L. Gordon Cooper, Jr., will execute a 10-fps posigrade burn to pull up perigee altitude 5 n. mi. in preparation for the rendezvous exercise.

The immediate task afterward will be to turn on the rendezvous radar, and to make an alignment check of the D-4 and D-7 experiment equipment provided by the Dept. of Defense. The DOD equipment will make radiometric measurements of natural and manmade objects in space across a wide band of the infrared-visible-ultraviolet spectrum.

Midway through the second orbit, the command pilot will yaw the spacecraft 90 degrees to the orbital path. At 2:07 elapsed time, the rendezvous evaluation pod (M/R, June 28, pp. 22-23) will be ejected from the spacecraft adapter, placing the object into an orbit slightly out of the plane with respect to the spacecraft's orbit. Cooper will turn the spacecraft around to face the REP and apply a 3-fps thrust out of plane to null the relative velocity between the two objects.

The spacecraft will stay with the REP in a station-keeping maneuver for 52 min. while the command pilot aligns the object in a reticle mounted on his window. Radiometric measuring equipment will have been rotated out from the adapter section by this time to begin infrared measurements of the REP.

The sensor will track the space-cooled object from the day into the night side of the orbit. Described by the Air Force as an interferometer spectrometer cooled by liquid neon to 27°K (−410.6°F), the sensor will get an IR signature of the REP in the 8 to 12 micron region.

The DOD package contains two other sensors: a radiometer with three detectors in regions ranging from 0.2 to 0.7 microns, 1 to 2 microns, and 4 to 12 microns; and a non-cooled interferometer spectrometer with two detectors in regions ranging from 1 to 3 microns and 3 to 12 microns.

● **Further maneuvers**—Immediately after the rendezvous exercise, Cooper will aim the DOD sensors at the Moon, then moving into third quarter, to obtain its spectral response. Later in the mission, the DOD equipment will track missiles launched from Cape Kennedy and from Vandenberg AFB.

At 2:59 elapsed time, the spacecraft will execute a 15-fps separation burn, placing it in a higher and relatively slower angular rate of travel around the Earth.

A maneuver to start closing the distance between the two objects is planned near Ascension Island at 3:39 elapsed time. The velocity imparted here—updated by the ground to absorb launch dispersions—will move the spacecraft gradually into a lower and faster (shorter-period) orbit. The spacecraft will start gaining on the REP from a maximum trailing distance of 45 n. mi.

At 4:31 elapsed time, when the spacecraft has descended six miles below the REP in altitude, the third and final coelliptic maneuver of 30 fps retrograde will be made. This will place the spacecraft totally within the REP's orbit, thus setting up the concentric rendezvous trajectory that will be used during the *Gemini-6* mission with the *Agena* target vehicle.

The radar will be feeding range, range rate, azimuth and elevation information to the onboard *Gemini* computer, which will be solving for Δ V and direction to place the spacecraft on a collision course with the REP. Cooper will execute a 16-fps terminal phase maneuver as soon as a look angle of 28 degrees up from the spacecraft's path is acquired. The spacecraft will be six miles below and twelve miles back of the REP at this time.

● **Adjustments**—The thrust, at approximately 5:04 elapsed time, will be initiated along the 28-degree line-of-sight to the REP and will occur about 130 degrees of orbital travel back from the point of rendezvous. Two mid-course corrections will be applied at 82 degrees and 34 degrees from rendezvous.

The onboard computer will be collecting platform and radar data, processing it and comparing its values to predetermined values within the computer based on Clohessey-Wiltshire equations of relative motion between two vehicles in space. The necessary adjustment in velocity to accomplish a rendezvous will be displayed to the pilot every two minutes on the inertial velocity increment (IVI) indicators.

The braking maneuver will be made at 5:36 elapsed time over Carnarvon and midway through the night side of the fourth orbit. The rendezvous will be considered accomplished when the spacecraft nulls relative velocity with the pod and is within 20 to 100 ft. of it.

Tindall said that from 200 to 250 lbs. of orbital attitude and maneuvering system fuel has been allotted for the rendezvous exercise. From 400 to 450 lbs. will be carried on the spacecraft.

The next launch of a *Gemini—GT-6*, scheduled for late October or early November—will mark the first actual rendezvous and docking attempt with an *Agena* upper stage. Each of the six planned rendezvous missions will last only two days. ■

Technical Countdown

PROPULSION

LPC Fires Highest-Impulse Hybrid

The highest energy output achieved to date in a hybrid system was reached during a recent set of static firings by Lockheed Propulsion Co. The motor was the fourth to exceed sea level-delivered Isp in excess of 325 sec. Two different hybrid rocket propellant combinations were used in the tests. The fuels were solids in all cases and the liquids were ambient-temperature oxidizers.

Hercules Fires Standard Missile One

A dual-thrust firing of the Navy's Standard Missile One motor by Hercules Powder Co. at White Sands successfully passed a series of radar attenuation tests. The end-burning unit contains both the booster and the sustainer in the same maraging steel motor case. The motor was developed by Allegany Ballistic Lab for the Navy and the high-energy propellant was specifically designed to eliminate radar attenuation problems.

156-in. Glass Case To Be Burst

A three-segment, 156-in.-dia., 50-ft.-long filament-wound solid rocket motor case will be burst during full-scale hydro tests at Thiokol Chemical Corp.'s Wasatch Div. Case design burst pressure is about 1,200 psi. Thiokol officials said subscale testing of a two-segment, 44-in.-dia. case was extremely successful. This case burst at a chamber pressure of 1,980 psi. The massive case program in filament winding is funded by the Air Force's Materials Technology Lab at Wright-Patterson AFB. The main achievement in a successful full-scale test will be the performance of the clevis-tongue segment joints fabricated from a laminate of steel shims and a glass fiber/resin matrix. A second 260-in.dia. case is being fabricated by Aerojet-General Corp.

New Chamber at Bunker-Ramo

A 512-cu.-ft. walk-in temperature-humidity-altitude chamber is in operation at Bunker-Ramo's Environmental Test Lab. The unit can raise the temperature of a 2,000-lb. sample at the rate of 7.5°F/min. and decrease it at 2.5°F/min. over the entire operating range of —100° to 350°F. The maximum altitude ability is 250,000 ft., attainable some 60 minutes starting from ambient pressure. Humidity environments of 20% to 99% can be obtained up to 185°F with a 4-kw live load. The chamber will be used by the lab's customers and the technical community.

GEODESY

Pageos Program Announced

An *Echo*-type satellite will be developed by Goodyear Aerospace Corp. to help determine the relative location of land masses on the Earth's surface. Known as the *Passive Geodetical Satellite* (*Pageos*), the 100-ft.-dia. orbiter will be used in connection with 36 ground stations around the world to determine the boundaries of all countries in relation to one another. The aim is to provide a 10- to 100-fold improvement in accuracies now available. Scheduled for launch in the second quarter of 1966, the package will be delivered to its 2,650-mi. altitude by a *Thrust-Augmented Thor/Delta D* combination. Photometric techniques were developed by Goodyear Aerospace for measurement of the stability and solar light reflectance of the *Echo I* satellite. These measurements indicated the possibility of using *Echo I* over long periods of time as a passive, specular, solar-reflecting target for geodetic triangulation.

ELECTRONICS

Laser Target Illumination Demonstrated

A recent flight test has demonstrated the accuracy of supersonic missile guidance against a small target illuminated by a laser beam. Under a privately sponsored effort by the Pomona Div. of General Dynamics, target illumination was provided by a laser illluminator developed by the division's advanced technology labs. The narrow beam greatly aided in rejection of background radiation. Missile used was a supersonic, lightweight test vehicle. Characteristics of the vehicle were compatible in all respects with launching either adjacent to or remote from the illuminator location. Techniques demonstrated are applicable to interception of both surface and air targets.

Spacecraft Power Systems Simulated

A simulator designed to test compatibility of individual components in spacecraft electrical power systems is in operation at Westinghouse Electric's Aerospace Electrical Div., Lima, Ohio. The device has all of the key elements of a typical space electric power system. Two adjustable power supplies provide inputs to simulate electrical characteristics form sources such as solar cells, fuel cells and other static generation devices. In event of a malfunction, the simulator automatically isolates the fault, and protection logic circuitry substitutes alternate components or paths in order to keep the system working.

SPACE MEDICINE

'Wolf Trap' Sampler To Be Tested Further

Tests will begin this fall on a five-chambered version of the "Wolf Trap," an instrument designed by Prof. Wolf Vishniac of the University of Rochester's Biology Department. The flight-engineering model, about the size of a cigar box, is being built by Ball Brothers Research Corp. for NASA. The Wolf Trap recently proved successful in its first field test, conducted near Death Valley, Calif. Eighteen hours after it took a sample from the desert soil, the device began registering the presence of microorganisms, and recorded their exponential growth for the next 12 hours.

Avco Studying Blood Flow

The Office of Naval Research is funding an Avco-Everett Research Laboratory study of the blood-flow problems of artificial hearts. Applying experience in fluid dynamics research Avco hopes to develop a better understanding of the relation of flow conditions to blood clot formation, a major problem in the development of prosthetic heart devices.

Dehydration Cuts Acceleration Tolerance

Douglas Missiles and Space Systems Group has demonstrated in tests run on its centrifuge that dehydration causes a decrease in human tolarance to positive acceleration amounting to 15% to 18%. Study was conducted in an effort to understand the causes of the orthostatic hypotension which has affected several of the astronauts—most markedly Walter Schirra and Gordon Cooper—after their spaceflights.

GT-5 To Report on Astronaut Vision

Experiment designed by Univ. of California to determine whether spaceflight sharpens eyesight; earlier tests conducted by Douglas

HOUSTON—Scientists at NASA's Manned Spacecraft Center (MSC) here are preparing experiments for *Gemini-Titan 5* in an attempt to get a definitive answer as to whether weightlessness or some other unique factor of spaceflight does indeed improve human visual acuity.

Astronauts' experiences to date, particularly those of L. Gordon Cooper, who told of seeing chimneys in Tibet and moving vehicles on roads in the Southwest U.S. desert, have already led to revised estimates of the old theory that the human eye cannot perceive objects smaller than one minute of arc. Such a theory is termed "naive" by Roswell W. Austin, a research physicist in the University of California's Visibility Laboratory, which is in charge of this *GT-5* experiment. Principal investigator is Dr. S. Q. Duntley.

The Air Force, with Douglas Aircraft Co. as contractor, has conducted experiments in weightless flights which indicate that brightness discrimination is considerably improved by the zero-g condition (M/R, June 21, p. 36).

Biomedical tests on subjects in a single- or two-gas environment over extended periods have shown no changes in visual acuity due to artificial atmosphere, NASA specialists say. However, prolonged exposure to zero-gravity may have some effect on pilots' ability to see objects on the ground, Austin said.

● **Tester**—An "in-flight vision tester" will be carried in the *GT-5* spacecraft for daily self-checks of pilot vision. The binocular-like instrument presents objects focused at infinity. The pilot discriminates the "orientation" of rectangles (vertical, horizontal, northeast-southwest, or northwest-southeast), reads his score and relays this information to the ground. The readings will be compared to preflight (and later postflight) readings for indication of any changes in visual acuity.

Individual training to familiarize astronauts in the use of the vision tester and the orientation discrimination task was performed in a specially instrumented training van at NASA's Manned Spacecraft Center under the direction of Robert Stapleford of the Visibility Laboratory. To collect baseline data, from eight to 12 two-hour training sessions were required of each crew member.

"We obtained the threshold contrast (that level of contrast and rectangle size which can be discerned by the pilot at least 50% of the time) for each man through many repeated presentations at five different levels of difficulty, or contrast," Stapleford said. "These levels range from their complete ability to discriminate down to the level where their response is only chance." He added that the data is then corrected for the chance factor.

Looking through the vision tester, the pilot will see one-by-four rectangles varying in size, orientation and contrast value. The instrument displays 36 objects in series of six—each series is rated according to a known contrast value beginning with —1.0000 (black on white background). Within each contrast group, the rectangles vary in size and orientation. The sizes in the higher-contrast groups vary from 3 minutes down to 0.2000 minute of arc. In the lower-contrast groups, the sizes of the rectangles descend from 4.5 minutes of arc to 1.125 minutes of arc.

"These are in such a degree of difficulty that a person with normal 20-20 vision has considerable difficulty in properly determining the orientation of the smaller objects," Austin said. "The astronauts we have measured have considerably better than normal vision. *GT-5* pilot Charles Conrad so far holds the record on our vision tester; he missed only two and these were the smallest rectangles in the low-contrast group."

● **Bite board**—Prior to using the vision tester, each astronaut will insert his own bite board into the instrument to align the optical axes of the eyepieces with the optical axes of his two eyes. This removes any variation in vision measurement that could be held accountable for misalignment of the instrument during day-to-day checks.

A small data card is also inserted into the vision tester to record the pilot's score. Correct choices are read as perforations in black squares. The pilot counts the right combinations and radios his score to the ground.

● **Target plans**—Daily scores of the pilots will have some control over the size of "targets" laid out at two sites: north of Laredo, Tex., and south of Carnarvon, Australia. These will be read by the pilots as the spacecraft passes overhead. "We're starting out with a known contrast on the ground, using rectangular patterns just as in the vision tester," Austin explained. Special ground instrumentation will be used to measure attenuation and scattering effects of the atmosphere, variations in slant range from pass to pass, and lighting conditions.

The desert floor at both sites has been cleared, plowed and dragged into squares, 2,000 x 2,000 ft., within which have been patterned one-by-four rectangles of random size and orientation.

Between spacecraft passes overhead, ground teams using manure spreaders, bulldozers and trucks will change the size and orientation of the rectangles according to the pilots' scores and according to the slant range distance of the spacecraft to the site, which is a function of the difference between the Earth's daily rotational period and the spacecraft's orbital period of 90 minutes.

● **Transmittance loss**—A perturbation (regression of the node) due to Earth's oblateness causes an eastward movement of the day-night lines by eight to 10 degrees of longitude per day. The Laredo site will be visible in the mornings during the early part of the mission, and the Carnarvon site will move into the late afternoons beginning about the fifth day, depending on the actual liftoff time of the *GT-5*.

There will be some loss of contrast transmittance through the spacecraft window, and probably a great amount of light scattering from a buildup of deposits on the windshield, Austin said. Experts attribute this scattering to deposits of foreign matter from spacecraft thrusters and outgassing materials. ■

H_2O_2 Oxidizer Challenges Other High-Energy Propulsion Compounds

by John F. Judge

A 98% HYDROGEN PEROXIDE oxidizer manufactured by the Inorganic Chemicals Div. of FMC Corp. matches or operationally exceeds the performance of most high-energy compounds currently under study for advanced propulsion applications.

In addition, the peroxide can be used in boost, upper stage and space propulsion in the same or different vehicles and combined with all of the more energetic metallized fuels.

The compound has a potential as a monopropellant and as an energy source for fuel cells. Its storage and handling characteristics meet almost every test in all applications listed.

James C. McCormick, head of technical sales-propulsion for the Buffalo, N.Y., Division, told MISSILES AND ROCKETS that present liquid and solid engines give exhaust velocities approaching 10,000 fps with vacuum specific impulses in the 330-sec. area.

● **Hydride combinations**—McCormick says the most promising propellant combinations showing advances in theoretical performance are those using 98% hydrogen peroxide or nitrogen tetroxide as the oxidant and the hydride of some light metal as the fuel.

While these combinations are not as energetic as the cryogenics, the decreased problems in handling and storage offset the disparity in specific impulse. Metal hydride fuels such as beryllium hydride, aluminum hydride, lithium aluminum hydride, butyl rubber and butyl rubber/aluminum give high theoretical Isp with 98% H_2O_2. These impulses are higher than those expected with the nitorgen tetroxide or chlorine trifluoride oxidized systems.

McCormick points to tests with 90% and 98% H_2O_2—Hydracarbon hybrid systems (polyethylene) showing burning rates in the 0.025-ips range. The substitution of butyl rubber increases this rate and simplifies the fuel grain designs with no loss in specific impulse.

McCormick cites an impulse of 277 sec. at 1,000 psia chamber pressure to 14.7 psia and a density of 1.34—but when operating this system under a chamber pressure of 1,000 psia to 0.2 psia, the vacuum Isp jumped to 344 sec. at 1.35 density with 98% H_2O_2.

If 41% by weight of the fuel charge contains aluminum and 98-99% peroxide is used, the Isp becomes 294 sec. (a 1,000 psi chamber pressure at sea level conditions.) Vacuum Isp moves up to 349 sec., a density impulse value of 485 sec.

McCormick claims this system has a potential in both booster and upper stage propulsion schemes stemming from the low fuel grain cost and a favorable density impulse.

Similar tests with the 90% H_2O_2—lithium aluminum hydride system showed a 94% corrected efficiency. McCormick says this is a workhorse combination giving an Isp of 300 sec. at 1,000/14.7 psia and 360 sec. under vacuum conditions.

The burning rate in this case was uniform at 0.3 to 0.4 ips. The substitu-

A COMPARISON of three non-cryogenic oxidizers drawn by FMC Corp.'s James C. McCormick from information supplied by the Callery Chemical Co. Conditions are optimum expansion at 1,000 psia/0.2 psia.

Fuel	H_2O_2			N_2O_4			ClF_3		
	Isp	Dens.	F.T.	Isp	Dens.	F.T.	Isp	Dens.	F.T.
BeH_2	498	-----	3884°K	462	-----	3446°K	418	-----	4500°K
AlH_3	424	1.58	3923	401	1.55	4292	367	1.79	4693
B_5H_9	405	1.02	3100	391	1.12	4388	368	1.47	4543
H_2	385	.589	2912	408	.460	3254	378	.612	3985
MgH_2	368	1.45	3073	347	1.44	3265	349	1.72	4465
C_4N_2	350	1.30	3257	261	1.24	4034	325	1.62	3404
UDMH	349	1.25	2992	354	1.18	3433	337	1.37	3794
N_2H_4	348	1.27	2916	354	1.21	3262	345	1.48	2969
CH_2	344	1.35	2979	344	1.34	2979	315	1.48	3541
LIH	341	1.26	2711	325	1.20	3171	360	1.52	4109

tion of 98% peroxide in the system increases the impulse by 15 sec. and the density by some 3 to 5%.

The FMC expert says beryllium hydride oxidized by the 98% peroxide results in the most rewarding propulsion system—a theoretical Isp of 498 sec. under vacuum conditions at 1,000 psi chamber pressure. This is topped only by the fluorine-beryllium hydride system performance at 501 sec. Isp.

The reaction temperature of the fluorine system—5,194°K—is well above the peroxide's 3,884°K so that sufficient dissociation of the fluorine system products is possible with a corresponding decrease in the realized impulse below that of the peroxide system.

The reaction temperatures of nitrogen tetroxide and chlorine trifluoride systems are higher than those calculated for 98% peroxide and beryllium hydride, pentaborane, aluminum hydride, hydrogen, magnesium hydride, butyl rubber and lithium hydride as fuels.

● **Direct substitution**—The 98% peroxide has the potential of uprating present 90% systems through newly developed screen type catalyst packs in monopropellant applications.

These new packs should also be useful in 98% peroxide-metallized fuel systems since rapid and safe ignition of the fuel is assured. In addition, the decomposition gas from the 98% peroxide—oxygen and water vapor at 1,750° F—can ignite fuel grains in hybrid engines, ignite liquid fuels, or drive turbo pumps or power thrust-vector-control systems.

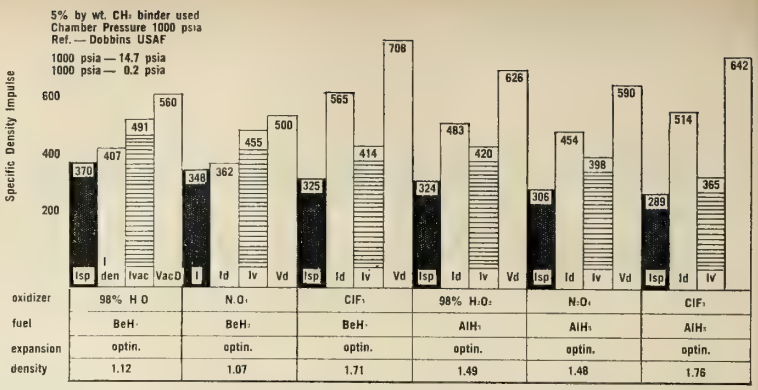
The 98% peroxide can be electrolyzed to furnish oxygen and hydrogen gas to power fuel cells and astronaut breathing requirements can be met with the excess oxygen involved.

In fuel cell applications, the 98% peroxide can also be used to power a bipropellant attitude control system—resulting in an economical, multi-use application area.

Storage tests indicate the 98% peroxide can be sealed in space vehicle tankage for periods of months. Three-year storage in 30-gallon pure aluminum drums show less than 0.1% oxygen loss per year.

Sealed storage tests in 1-gallon missile-type bladder-lined tanks show a 10 to 12-psi pressure rise in 2 months, but this would be less in larger tanks. Oxygen loss decreases of 200% to 500% can be achieved using specially stabilized 98% peroxide in stainless steel enclosures. Oxygen loss decreases of 50% to 100% can be reached with the 98% formulation in both bladders and aluminum containers.

Becco 90% peroxide was stored for some 18 months aboard the *Syncom II* satellite while giving high performance



COMPARISON of 98% H_2O_2 with N_2O_4 and ClF_3 in various hybrid systems.

throughout the period. McCormick says specific bladder materials such as Aclar (Allied Chemical Corp.), Fluorel (3M Co.), and Vicone 185 (North American Aviation, Inc.) have an excellent compatibility with the 98% form of the peroxide.

● **Cooling Capacity**—Pratt & Whitney Aircraft's heat transfer tests with electrically heated 316 stainless tubes showed that the 98% peroxide has the makings of an excellent coolant, says McCormick.

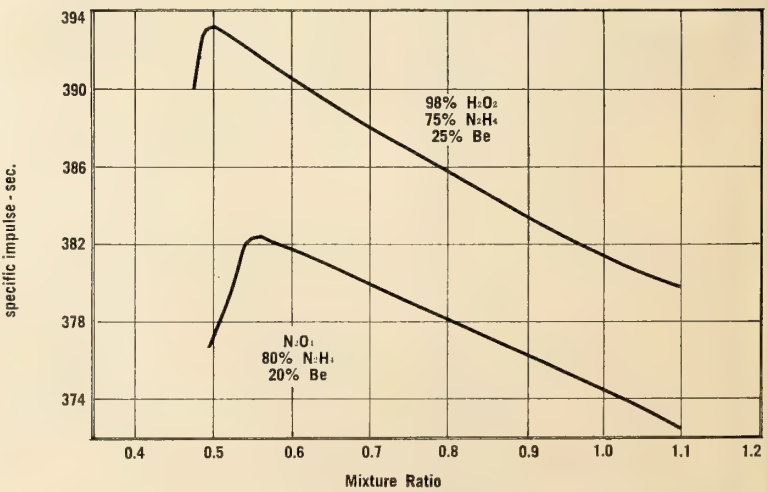
Even at lower velocities and considerably reduced peak heat fluxes, it compares favorably with other propellants. The tube tests proved the 98% peroxide is comparable to water as a coolant but without the nucleant boiling region.

In addition, McCormick says that the peroxide flow in a rocket engine—especially at the throat—would be redirected rapidly and the thickness of the gas film would be reduced. As a result, the bulk fluid temperature would increase to a still higher heat flux.

An extended test showed that a rocket cooling system using the 98% peroxide can be expected to operate for relatively long periods without any large change in heat transfer characteristics. This expectation has already been confirmed by North American Aviation's *AR-2* rocket which is regeneratively cooled with electrolytic process 90% hydrogen peroxide.

McCormick claims irradiation tests show little or no effect. The Van Allen belt dosage should increase the peroxide temperature only 0.2 calorie per gram during a year's voyage. *Mariner 2* data shows that radiation exposure on a Venus trip would not have been harmful to the peroxide. ■

COMPARISON OF 98% H_2O_2 and N_2O_4 systems with N_2H_4 +Be metal. Chamber pressure is 1,000 psia into a vacuum. Ac/At is 40/1. Data was provided by Aerojet-General Corp.



'Cap Pistol' Engines Coming of Age

Minute Curtiss-Wright WSR-4 solid-propellant engines tested for future spaceflight; could be used for EVA or spacecraft control

by David A. Anderton

WOOD-RIDGE, N.J.—Curtiss-Wright Corp.'s WSR-4 rocket motors—developed from the "Cap Pistol" concept—are undergoing final qualification and flight acceptance tests aimed at future flights aboard orbiting spacecraft.

The WSR-4 is a tiny solid-propellant rocket motor with a total impulse of 0.1 lb.-sec. and a nominal thrust of 4.0 lbs. It is a direct descendant of the WSR-2 motor which developed a total impulse on the order of 0.01 lb. per second.

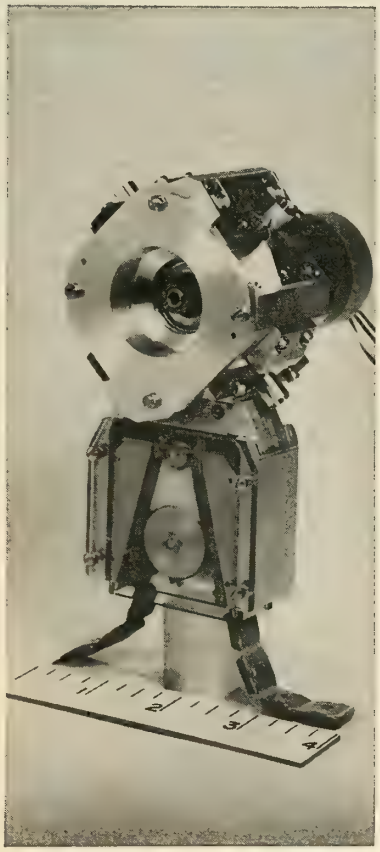
The larger impulse of the WSR-4 makes it a candidate for astronauts' back-pack maneuvering units, or hand-held thrusters for extra-vehicular operations. It could also provide precise orbital control of spacecraft.

On a weight and volume basis, say Wright Aeronautical Division engineers, the motors are competitive with the best of other systems. They say that they are feeling the most competitive pressure from hydrazine monopropellant systems, but that the subliming rocket, peroxide rocket, and gravity-gradient systems also provide tough competition.

● **How it works**—The WSR-4 follows the basic Cap Pistol technology by mounting its solid-propellant charges on a plastic feed tape. The motor consists of a layered assembly of a nozzle base plate, a propellant grain, an igniter, and an expandable "E" dome section, which serves to house the motor assembly.

The feed tape is led through a wheel shaped and assembled so that it forms a series of pressure vessels into which the solid-propellant motor partially fits. When ignition occurs, the combustion process expands the dome, forcing it against the side of the wheel cutout to form a combustion chamber. Use of the dome makes possible a higher combustion chamber and improved motor performance. It also makes for a more repeatable set of data because of the dimensional consistency of the motor's combustion chamber.

Chamber pressure of the WSR-4 is 2,000 psia, compared to about half that value for the WSR-2 Cap Pistol. Weight of the -4 propellant grain is 0.00043 lb.



CURTISS-WRIGHT'S WSR-4 engine vectoring pulser.

Total weight of the assembled motor is 0.0213 lb. The inert material weighs 0.01065 lb., making the ratio mass 0.5.

● **Automated production**—The difficulties of building such a small motor are obvious. The motor itself is less than ½ inch square and less than ⅛ inch thick. This, however, is large enough compared with the WSR-2 units, which were about the size of half of the cross-section of an ordinary lead pencil, that WAD production engineers are studying ways to automate their assembly.

First motivation for this is cost. Any hand assembly operation is expensive. But there is also a great concern with quality control, with dimensional consistency and with getting the exact weights of propellant and igniter.

Spacing of the motors on the feed tape is also critical. The tape punching that serves as the feed control for the motor assembly is performed in the same operation that mounts the capsules on the tape.

Use of the motors requires an assembly of the feed wheel with a stepping electric motor fed with a tape of some specified number of motor charges. The stepping motor drives the tape into position for the firing, and moves the empty tape out to position the next charge.

● **Vectoring unit**—Four of these basic WSR-4 designs have been assembled into a developmental vectoring pulser unit. This assembly would not quite cover a 3x5-in. file card. The tape storage requires additional volume.

A 12-position stepping motor driven by a 28-vdc power supply moves the tape/motor assembly through the pulser. Firing cycling can be varied to ignite 5, 10 or 20 motors per second.

Propellants and igniter are Curtiss-Wright proprietary developments. They and all other materials used in the motor assemblies have been separately qualified in thermal vacuum, vibration and acceleration. They meet or exceed the specifications established by the National Aeronautics and Space Administration for experimental equipment to fly aboard the *Delta* launch vehicles.

Two developmental units were subjected to radiation tests. One was radiated for a 1-year simulated stay in an orbit between 300 and 3,000 miles high, corresponding to the Van Allen Belt conditions. The second capsule was radiated for a simulated 10-year orbit time. Neither showed any deterioration, and both were fired successfully at the completion of the radiation tests.

(*Continued on page 27*)

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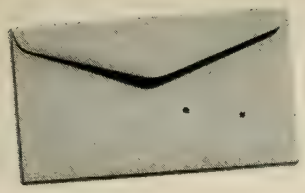

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Propulsion Design
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Advanced Propulsion systems
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Control Systems Engineers
Design, analysis: Nike-Zeus, Thor.

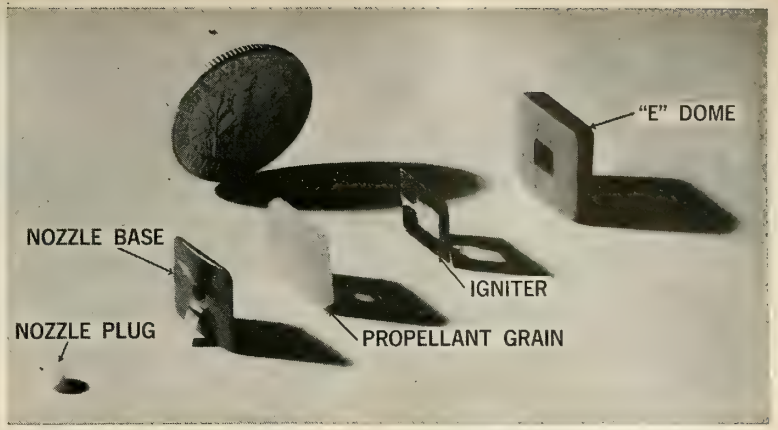
Ground Support Equipment
Design & test ground support equipment. Design electrical systems.

Chemist/Chemical Engineer
Design, develop: Electrochemical, life support devices and pre-treatment techniques for waste fluids.

Chemist—Fuel Cells
Applied electrode technology catalysis, or electrochemical technology.

Mathematician
PhD. Help make new, special purpose computers/programs.

Battery Technologists
Design, fabricate, test: High energy density batteries, electrodes, separators, cases, seals, components.



BREAKDOWN OF WSR-4 motor.

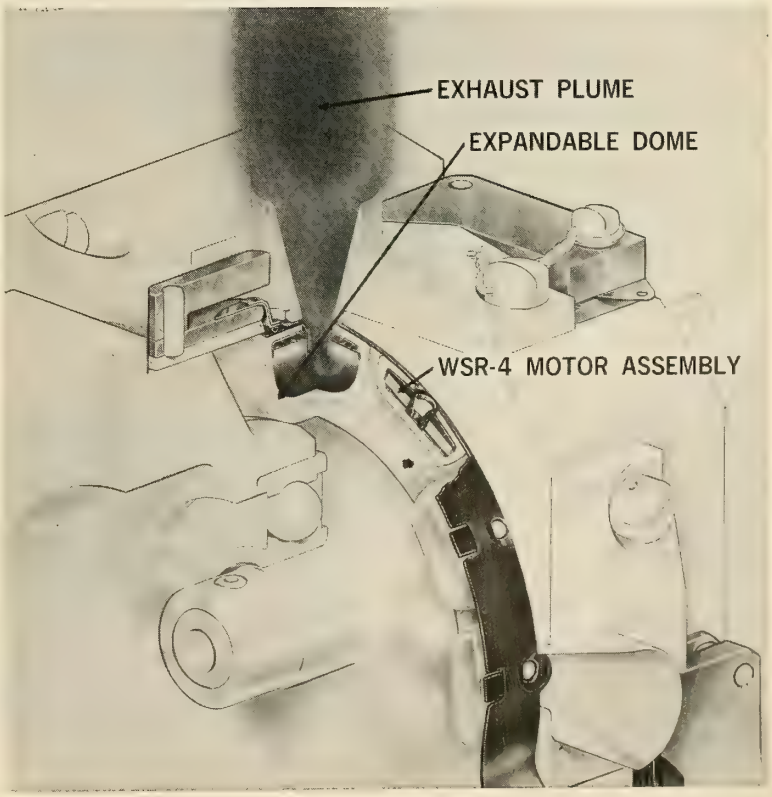
The Cap Pistol concept traces its origin to a 1961 feasibility study which developed the WSR-1, a unit with a total impulse of 0.008 lb.-sec. That unit was developed into the WSR-2 of equal impulse.

Later came the WSR-3, using the same design details as the -2 model, but scaled up by a factor of ten on performance. This led to the WSR-4 with its total impulse of 0.10 lb.-sec.

The next step is to increase the performance again, probably by another order of magnitude so that the total impulse would approximate 1.0 lb.-sec. Current estimates made by WAD engineers indicate that there is an upper limit to total impulse at about 5.0 lb.-sec. above which the Cap Pistol concept is no longer competitive with other types of micro-rocket powerplants.

Program for the development of the Cap Pistol motors has been under the sponsorship of the Solids Division of the Air Force Propulsion Laboratory at Edwards AFB, Calif. ■

CUTAWAY VIEW of "cap pistol" motor in operation.



VAD Group Processed Mariner Photos

Same equipment used for Ranger Moon picture develops Martian series; Surveyor will have separate facility

by Rex Pay

PASADENA, CALIF.—Television signals relayed to Earth by *Mariner IV* were converted into pictures by the Video Advanced Development Group at Jet Propulsion Laboratory here, using the same equipment that processed the *Ranger* Moon pictures.

The VAD Group's equipment was built up as part of a research and development program. Because it is the only suitable equipment in existence, however, it was used as the production hardware for *Ranger* and *Mariner* pictures.

Surveyor will have its own photographic support system at the Space Flight Operations Facility, JPL, to provide pictures to experimenters within 15 minutes of their reception as video signals. The system is to be installed this fall.

The VAD Group will continue to investigate digital processing techniques and to develop new items of equipment.

At present the Group has an analog-tape to digital-tape converter that can operate with very poor analog signal-noise ratios, and a Video Film Converter that can convert analog or digital data to 35-mm film, or derive digital information from 35-mm film.

These two items of equipment are currently being upgraded so that they will interface directly with a computer. At present, the Group's computations are carried out by batch-processing on one of JPL's three IBM 7094's.

● **Unique animal**—Development of computer programs for video data processing is a difficult problem. "Concepts and techniques for these programs are just different from scientific programs," explained Frederic C. Billingsley, Supervisor of the VAD Group.

If the group's two present items of equipment were coupled to a computer, together with a scan converter, an on-line program development facility would be available. Once a program had been de-bugged it could be batch-processed on the IBM 7094.

Initial impetus for the digital video processing came from estimates made about three years ago that the poor quality of television cameras would require extensive correction of the pictures they transmitted.

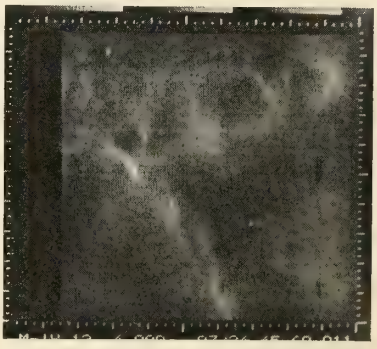
Two groups of programs were developed at first: ICOR, to correct the light levels in a picture, and GEOM, to correct geometric distortion.

Camera quality improved over the intervening years, however. When the *Ranger* pictures finally returned they could be released initially without these corrections.

A similar situation exists with *Mariner*. The camera is not considered to be as good as those on *Ranger*, but it did provide pictures that do not require ICOR or GEOM corrections initially.

● **Lessons from Ranger**—These programs are of course used when accurate measurements have to be made from the pictures. ICOR has been used to take out the uneven shading in some of the *Ranger* series, but the NASA volumes of *Ranger* pictures are hand-dodged. GEOM will be used when stereoscopic pairs are produced from the *Ranger* pictures.

Program development for video processing has been carried out by Mesa Scientific Co. under the guidance of Dr. Robert Nathan, Space Sciences Divisions, JPL.



THIRTEENTH Mariner IV photo shows Mare and bright region Phaethontis.

One new program important to the *Ranger* pictures is removal of a spurious erase signal that leaked into one television channel from another. Random interference is removed by a program that compares one TV scan line with its two neighbors to eliminate extreme changes due to noise. Another program enables contour maps to be drawn from the digitized photographs.

All of these programs were available for processing the *Mariner* pictures, said Billingsley.

● **Key converter**—The Video Film Converter was developed to JPL's specifications by the Link Division of General Precision. It is a flying-spot scanner device that in essence is a precision CRT film recorder and film scanner. The VFC can record analog pictures over a wide range of sweep rates, it can produce pictures from digital tape over a wide range of digitized densities, and it can scan and digitize transparencies.

The VAD group has gone to great lengths to produce a raster with extreme geometric linearity, a scanning spot with precisely known intensity, and a collection of adjustable analog and digital sweep circuits.

"It has required several years' work to bring the state of the art up to the level of producing acceptable pictures," said Billingsley. Non-linear variation of spot intensity with drive voltage was overcome by use of a feedback loop. To provide adequate frequency response, a P-16 phosphor had to be used in the CRT instead of the more conventional P-11. Gamma correction can be inserted into the VFC, but this has been a minor problem so far and has not received attention.

A 1:1 magnification, between the film on which the image is written and the CRT tube, is used to minimize geometric distortion. Thus the resolution of the film is that of the CRT.

On the film the half-amplitude spot diameter is 30-35 microns, or about 0.0014 in.

● **Dealing with distortion**—No pin-

cushion correction coils are used with the CRT. Although these can make the picture frame appear undistorted, they do not correct accurately across the raster. With the present one-inch raster for the 35-mm film of *Ranger* and *Mariner*, the system is satisfactory. But with the increased raster size of *Surveyor* (2¼ in. square for 70-mm film) the pin cushion distortion will be more objectionable.

To overcome this, use will be made of non-linear sweep drives, with corrections calculated electronically. JPL and Link have found that very accurate work can be done this way. "It is entirely a practical piece of circuitry," said Billingsley.

There is the capability of analog or digital sweeps in the horizontal in the VFC. But in the vertical direction only digital stepping is available. At present each direction can only be stepped incrementally. In future Billingsley would hope to be able to command the spot to selected points in the raster in any desired sequence.

This would give the capability of going to any point in a picture and then moving the spot around that point in any manner to draw a contour or to follow some special photogrammetric procedure.

• **Trade-offs studied**—"It seems to me that a pure digital computer approach is not required," said Billingsley, "a more optimum solution is by means of a computer and external hardware that is computer-controlled to do some of the processing. One of our long-range goals is to determine trade-offs between computer and hardware."

Similarly, he said, the question of whether digital or analog computer techniques are best suited to certain problems will be investigated.

"I have the feeling that computer-controlled analog computation at some stage in the process is better than doing it all in the computer itself," said Billingsley. "In some areas actual optical processing may be optimum."

The video film converter has controls to allow the picture to be rotated with an accuracy of 0.1 degree. The number of scan lines and the spacing can also be adjusted. In effect the operator can zero in on any part of a picture.

Direct production of digital tapes from analog video tapes is carried out with a system that uses a 15-kc digital recorder. At present this requires that a *Ranger* analog tape is run through the system at quarter speed for eight successive runs. A new system is being procured that will use a 96-kc digital recorder. A digital tape will then be produced with one play through at one-eighth speed. ■

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Voyager Sterilization Sets Precedent

Specifications must satisfy both biologists and design engineers; requirement will apply to most space programs in next century

by Heather M. David

THE CRITICAL PROBLEM of sterilization of the *Voyager* spacecraft is putting pressure on NASA to come up with standards acceptable to biologists but feasible in terms of spacecraft engineering design.

A sizeable effort is under way at various NASA centers to tie down all the facets of the problem—the Jet Propulsion Laboratory being concerned primarily with spacecraft and component design techniques, Goddard Space Flight Center with definition of the upper limits of the Earth's biosphere in order to determine the problems of contamination of the outward-bound spacecraft, and Headquarters with a variety of studies on biological aspects, including assay and control.

According to Lawrence B. Hall, a Public Health Service official assigned to NASA as a special assistant for planetary quarantine, the problem of ensuring that *Voyager* meets the requirements—that the chances be less than 1 in 10,000 that there be a single living cell anywhere in the spacecraft—is extremely difficult but not insurmountable. Although it will require advances in the state of the art to accomplish, Hall pointed out, designers must face the fact that the majority of the space programs for the next 50 to 100 years will bear this requirement.

The sterilization requirement led to considerable difficulty on the *Ranger* program. As first planned, the spacecraft was to undergo both terminal heat and gas (ethylene oxide) sterilization procedures. Perhaps fortuitously for the engineers, the standards were later relaxed when the scientific community agreed that the Moon would not require the stringent procedures necessary for probes impacting the planets.

No attempt was made to decontaminate the *Mariner* spacecraft, but the program met the objectives set by the Committee on Space Research that unsterile fly-by spacecraft must have less than a chance of 3×10^{-5} of impacting the planet. *Mariner IV's* chances were computed to be on this order at launch, but as maneuvers were successfully initiated to refine its course, the probabilities decreased.

There was some concern, however, about possible microorganisms in the attitude control propellants since these might have been injected into a trajectory that would have lead it into the atmosphere of the planet. Two filters were designed in series to eliminate this problem, and the gases themselves were analyzed and found to be at a very low level of contamination. The possibility of contamination of Mars by this means, Hall said, was computed to be less than 10^{-12}.

- **Attack**—NASA has devised a number of requirements for construction of the *Voyager* spacecraft, which, it is hoped, will ensure its sterility. In drawing up such standards, it works closely with the Public Health Service, whose Sterility Control Laboratory at Phoenix, Ariz., is the basic authority on what microorganisms can be considered live or dead or on what constitutes life itself.

It has been pretty well determined that the rigors of the space environment cannot be depended upon to kill any Earth microorganisms. In fact, Hall points out, the very conditions of deep cold and low vacuum are those used to preserve microbial life in a technique of lyphilozation used in the preparation of vaccines and other laboratory procedures.

While ultraviolet will kill organisms over a long period of time, it reaches only exposed surfaces. Microbial life has been known to hide behind even a speck of dust, escaping from ultraviolet rays. Thus even the spacecraft's surface could not be considered to have been sterilized in this manner during the trip. Hard radiation cannot be expected to penetrate further than inches within the spacecraft, and thus also must be ruled out.

Actual spaceflight experience—both Soviet and U.S.—also has proved the almost complete survival of microorganisms in the space environment.

- **Sterilizable hardware**—The state of the art of developing hardware that can survive the high heat of sterilization treatment is moving ahead, Hall said, although the point of complete confidence has not been reached. While NASA feels sure that such devices will be flyable by 1973, earlier flight schedules might make it necessary to make some compromises in the optimum design of the spacecraft in order to use only components that will meet the reliability requirement. Industry has said that under real pressure, it could come up with the design by 1971, given the mission go-ahead.

Current NASA requirement is that the hardware must have a reliable 10,000-hour lifetime after withstanding a 145°C environment for 36 hours in pure nitrogen followed by a simulated deep-space environment. Hall said that similar studies will also be run on reliability of components, after adding a ethylene oxide treatment cycle.

- **Limit biological loading**—The second approach NASA is taking to the problem is in the development of methods to limit the numbers of biological specimens on and in the spacecraft as it is assembled, in order to cut down the time required for terminal sterilization.

This can be accomplished in two ways, Hall said. One approach is that every item be manufactured in downward laminar flow clean rooms that meet the Federal Specification 209 Class-100 clean-room standards. Smaller objects can be worked on on clean benches, which have ultra-filters regulating the air passing across the work, with final assembly in the clean room.

The second method of decontamination is by subjecting devices or components manufactured under normal conditions without clean-room procedures, to a low level heat soak. NASA will accept this procedure if carried out in one of a range of temperature/time combinations spanning 80°C for 280 hours, up to 145°C for 15 minutes.

Such temperatures often are used in the manufacture of some items, and in some cases contractors may find this an easier requirement to meet than that of

clean-room manufacture.

Environmental testing carried out at the manufacturer's facilities or at NASA laboratories presents a threat to the cleanliness of the spacecraft. For this reason, before the spacecraft is returned to the clean facility after testing, it must be put in a gaseous mixture of ethylene oxide (300 milligrams per liter) at 70°F, for 4 hours.

Some problems have arisen in ensuring the effectiveness of this treatment, Hall said, and the time may be increased. In addition, NASA now stipulates that the spacecraft must be exposed to more than 35% relative humidity for more than 72 hours since some of the dried organisms have been living through the experience.

Further study is necessary on the whole subject of the use of ethylene oxide, Hall said, since there have been some reports and many fears that it will damage or affect some compounds. Most suspect, if this is indeed a cause of damage, are polymers and adhesives.

While testing of the spacecraft is being carried on, personnel access will be restricted, and testing employees must wear deflection masks and protective clothing. Sterile rubber or plastic gloves must be worn at all times.

This entire list of procedures will by no means ensure sterility, but NASA hopes to limit the number of viable organisms to not more than 10^8 on or in the complete spacecraft to simplify the sterility problem. Even though this number of organisms may remain, Hall said, they will not multiply because there is no nutritive material on the spacecraft.

Radiation as a means of killing microorganisms is feasible, but is not being considered by NASA—unless very unusual circumstances arise which might make it necessary—since it is both dangerous to handle and damaging to components themselves.

● **Terminal sterilization**—When the spacecraft is assembled, it will receive a final heat sterilization together with a shroud which will protect it from organisms in the Earth's atmosphere until it is well out of the danger zone on its way to the planet. The sterilization container may be handled at the same time but separately in an oven-like device, or it may be sealed with the spacecraft inside and then put in the oven. However, whichever method NASA chooses, no handling of the flight spacecraft will take place after this time. Should the container be placed in the oven in an open position, it will be closed automatically or by remote control in the oven.

A range of time/temperature combinations for the terminal sterilization heat period again have been drawn up so that the program manager may make a choice of one based on critical components or perhaps on the basis of reliability data on the components in that particular spacecraft. It has been found that long exposures at low temperatures may be just as damaging to some components as high temperatures, even for short periods, are to others. The choices range from 105° for 336 hours, to 160°C for three hours.

● **Encapsulation of the spacecraft**—The spacecraft will then be contained in a sterilization container for test, checkout and launch. Access at this time will have to be made with hardlines or radio frequencies.

The capsule in its enclosure is mounted on the vehicle and not reopened until it reaches deep space. Should a malfunction occur in the spacecraft before the launch, sterilized backup spacecraft will be substituted. The original spacecraft would be opened, repaired, resterilized and held for later launch.

This whole procedure needs the greatest level of development, Hall said. At present, JPL is studying sterile assembly techniques to see if it is possible to enter the container but leave it sterile. ■

NASA Studies Danger of Astronaut Back-Contamination

NASA FACES some weighty decisions in the near future on the subject of what to do to guard against back-contamination of the Earth by spaceflight crews as well as contamination of other planetary surfaces.

The present requirement for *Apollo* says only that the spacecraft is to be handled for the last 20 days before launch in a clean-room atmosphere. However, there will be no attempt to sterilize the vehicle. The only other rule governing contamination on the flight is that biological wastes must not be discharged during the flight. Any wastes left on the lunar surface must be completely contained.

There are no requirements regarding *Gemini*, since wastes ejected in Earth orbit obviously will not reach any other planetary body.

● **Extraterrestrial threat**—However, the biggest concern is that returning *Apollo* astronauts might bring back alien microorganisms, either on their spacesuits or equipment or in samples taken from the lunar surface. NASA, through the Manned Spacecraft Center, has a contract in progress with Smith, Henchman and Grylls for the design of a lunar sample receiving station, the location for which has not been determined.

The Space Sciences Board of the National Academy of Sciences, under noted biologist Dr. Allan H. Brown, has made definite recommendations to the space agency regarding the procedures it thinks NASA should follow in regard to returning *Apollo* astronauts. In a document released earlier this year, it stated the opinion of a conference held by the Life Sciences Committee that astronauts returning from lunar or planetary missions should be placed in strict quarantine for 3 weeks upon return to Earth. In the case of lunar missions, the board said, the quarantine period should begin the moment of takeoff from the Moon.

This would require that the spacecraft, astronauts and all persons who have come in contact with them (presumably the recovery crews and all medical and debriefing personnel) would be put into an isolation environment for the quarantine period. Spacecraft, suits and equipment, the group recommended, should not be subjected to Earth contamination until biological studies can be made on them.

Samples returned to the Earth, the conference agreed, should be opened as promptly as possible and examined behind absolute biological barriers, under rigid bacterial and chemical isolation. Steps to formulate detailed operational procedures to permit the handling of such samples should immediately be taken, it said.

A trial run using non-pathogenic organisms was recommended for lunar and planetary missions to develop the most effective methods of minimizing the introduction of foreign matter into the capsule and to test the extent to which planned equipment may require modification. Astronauts should be trained in techniques to minimize inadvertent transfer of material, it said.

The conference also expressed the feeling that post-flight tests should include experiments specifically designed to identify organisms harmful to terrestrial plants and animals, through competition or disease.

Vast Potential Seen in Sea Minerals

Although a decade may be required to establish feasibility of ocean mining, prospects are bright; Lockheed, IMCC pioneering

by Robert Lindsey

TIBURON, CALIF.—Substantial opportunity for the aerospace industry is foreseen by officials of the U.S. Bureau of Mines Marine Mineral Technology Center, headquartered here, who are conducting the nation's first research and development effort to recover minerals from the ocean floor.

Lockheed Missiles & Space Co. and International Minerals & Chemical Corp. are working with the Bureau of Mines in the pioneering venture.

Officials here say that apart from the utilization of systems-analysis and engineering techniques and other R&D methods of the aerospace industry, if exploitation of marine minerals becomes technically and economically feasible there will be a rich market for ocean-mining hardware—systems whose development and fabrication seem to fall ideally within the competence of the industry.

They note, however, that it could take 10 years to determine such feasibility.

Although ocean mining's most obvious opportunities for the aerospace industry would arise from its know-how in advanced technologies and hostile environments, there may be isolated examples of more direct transfer. For example, John E. Crawford, Bureau of Mines' project coordinator, noted that one technique being considered for "coring" the ocean floor—obtaining samples of minerals for assaying—is a "two-way rocket," a propellant charge which would drive into the ocean floor, collect a sample and then return to the surface. Another example is the use of advanced materials from aerospace applications and transducers in underwater functions.

● **Long row to hoe**—Crawford said he personally feels it will take seven to 10 years to determine whether recovery of minerals from the sea is feasible. Even then, he said, the capability of recovering some minerals may not be utilized until deposits on dry land decline.

Much work has yet to be done. Crawford noted that diamonds are being recovered in 100 ft. of water off South Africa and coal, gold, iron ore and other minerals are being recovered in other parts of the world, but at no more than 200 ft. "When you start talking about deep-sea mining, there's going to have

SHIP NAMED "PERSPICACITY" is employed in joint Bureau of Mines-Lockheed Missiles & Space Co.-International Minerals & Chemical Corp. mining project.

to be a lot of research and development," he said.

Initially, the BOM-LMSC-IMC project is focusing on developing techniques for mining on the continental shelf—down to a 600 ft. depth.

Although the research team is trying to develop multi-purpose sea-mining techniques, Crawford said its first interest is in minerals already known to exist off the Pacific Coast, principally phosphorite; manganese; the black sands containing iron and titanium; precious metal sands, containing platinum, gold and silver; and green sands, bearing glauconite.

A University of California scientist estimates there is 1½ billion tons of phosphorite from 200 to 1,000 feet off the Pacific Coast. This mineral is a key element of fertilizer and has other potential uses.

Manganese nodules are believed plentiful off the coast, promising an abundant supply of this strategically important ingredient in the manufacture of steel. At present, the United States imports almost all of the manganese used in steel.

● **Austere program**—By today's standards of big government spending, the Bureau of Mines effort is being run on a shoestring. Crawford and a handful of aides started the project 18 months ago with an initial budget of $53,000, had $130,000 this fiscal year and hope for a $100,000 budget in FY 1966.

Headquarters for the project is a 60-year-old complex of dilapidated buildings and docks on San Francisco Bay built in 1904 as a coaling station, used later by the Navy as a net-laying depot and finally abandoned in the 1950's, until Crawford found it.

Renovation has been done by Crawford and his small group of engineers, oceanographers, and other technical people. Like its two vessels, most of the facility's laboratory and other equipment came from surplus sources.

Researchers are already sailing a small, converted Army freight boat which has been outfitted with an articulated hydraulic crane, hydraulic A-frame, hydraulic winches, a television system capable of operating down to 10,000 ft. with a 5,400 candlepower lighting system, and small mineral analysis laboratory. This fall, a 165-ft. surplus net layer, now being converted for its new job, will join the project.

In another example of the transfer of aerospace know-how to ocean mining, Lockheed information-handling specialists are designing a ship-shore system that will relay data from the ships to a computer center and data bank here for correlation and analysis.

● **Sampling pressed**—Crawford explained that ocean mining has three primary phases:

—Exploration—the location of mineral deposits under water.

—Sampling these mineral occurrences so they can be assayed and their value appraised.

—Recovery of the minerals—the mining.

The exploration phase, he said, is conducted by the U.S. Coast & Geodetic Survey and oceanographic research vessels. The BOM-LMSC-IMC project is concerned with the latter two phases.

J. Leslie Goodier, BOM engineering project leader, said the principal task now facing the researchers is developing methods for obtained "good-sized samples." In their exploratory work, geologists and oceanographers generally obtain only fundamental locations of minerals and small samples, Goodier said, "but we need more than a teaspoon; we need methods for sampling from which we can determine depth of a deposit, tonnage and grade."

Oceanographers use "grab" samplers yanked up from the ocean and gravity fall devices, but no available system, he said, "has been able to core very deep into hard sand."

Lockheed is now testing a new hydraulic rotary corer—much like an oil drilling rig—and has obtained an 8-ft.-deep core in relatively hard sand. "This was quite a breakthrough," Goodier said. The corer is dropped on a cable into the ocean, sets itself vertically on three pods and, under command of a deck-mounted electronic console, drills into the floor. Behind the drill bit is a hollow 8-ft. pipe that absorbs the strata as the drill penetrates. After it is withdrawn, the core is removed in a plastic envelope-like container and analyzed. If the operators so desire, the coring can be watched on television.

This coring device is one of several being considered. Ideally, Goodier said, the ocean miner wants a cubic yard of the sea floor; devices to bite out large chunks are being devised.

Beside the aforementioned "two-way-rocket," an explosive core device, "kind of an inverted shotgun," is being studied.

After sampling techniques are developed, Crawford said, emphasis will turn to actual mining techniques. He said several concepts are under study—including dredger-like systems, submerged crawlers and hydraulic ladders—but the most promising for the immediate future is an air flotation system that will suck up rocks and other materials like a vacuum cleaner.

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Goodier pointed out this system is not new, since the Egyptians are believed to have used the same idea thousands of years ago to lower the level of the Nile River. It would work like this:

A wide pipe of rubber or plastic would be placed over a mineral deposit which probably would have been loosened and perhaps broken into uniform pieces beforehand.

Air would be fed into the pipe through a manifold about a quarter or half way down. This frothing action reduces water density and creates a suction action, bringing up the material and depositing it in a barge. "As a mining device, the airlift system is the least expensive. All you do is supply compressed air. You don't have any complicated machinery and it picks up all the solids." But, he said, this system has some drawbacks, and ultimately "you'll have to go down below the surface and work. Submersibles of some kind will be used eventually for mining."

● **Soft sell**—Crawford said his group has been "besieged by industry," particularly high-level representatives of aerospace and chemical firms. A 41-year-old nuclear engineer, Crawford describes himself as an "optimistic skeptic" on the question of whether ocean mining will become a major enterprise. "I'm not convinced yet that we're going to mine the sea, but we have to go out and determine if these mineral occurrences are really resources, immediately or in the future, for what may be marginal or sub-marginal today may become valuable in the future. What may not be economically feasible today or tomorrow might be the day after tomorrow."

There is some international political impetus to developing ocean mining capibilities, because of a 1957 international law convention which stipulates that minerals found "under" the high seas can be exploited by any country with the technology to do so.

Crawford said he's not anxious for a sudden big push in ocean mining despite his austere budget. "I'd hate to see this suddenly become a multimillion-dollar program. At this point, there just isn't enough worthwhile to pursue; $500,000, maybe $1 million; that's about all we could intelligently spend at this point."

Conrad Welling, Lockheed's program manager on the ocean mining project, compares the prospect of recovering minerals from the sea with that of recovering petroleum from the ocean 25 years ago. Some companies, he said, scoffed at the idea; others began investing in exploration and technology development. "Now those oil companies who didn't jump into the ocean are finding themselves in a weak competitive position," he said.

Welling predicts ocean mining "will be an evolutionary process, with 90% of the advances through innovation rather than big breakthroughs." Experience of the oil industry will be very helpful, he said, and because of its diversity of talents and experience, the aerospace industry is well suited for exploiting the new ocean frontier.

"I think the probability for sea mining on a large scale is good. It will require extensive government, as well as industry, activity." ■

Life-Support System en Route to NASA-Langley

DOME-SHAPED test tank containing life-support system designed by Convair Div. of General Dynamics to sustain four astronauts in space for one year is shown prior to leaving San Diego by ship July 29 for Langley Research Center, Va.

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Mergers and Acquisitions

Teledyne, Inc., Hawthorne, Calif., and Microwave Electronics Corp. of Palo Alto have agreed to a merger that will result in MEC's operating as a division of Teledyne with its present management and personnel. MEC's product line of traveling-wave tubes, backward-wave oscillators and microwave solid-state devices will be added to Teledyne's electronics products. Terms of the agreement call for one share of Teledyne common to be exchanged for each seven shares of MEC stock outstanding. . . . *Consolidated Electrodynamics Corp., Pasadena, Calif., a subsidiary of Bell & Howell, has acquired the assets of Electrowest, Inc., Sacramento, Calif., manufacturers of temperature sensors and associated systems.* . . . NTH Products, Inc., El Cajon, Calif., has been merged into Carpenter Steel Co. of Reading, Pa. NTH, formerly a Carpenter subsidiary, will be known in the future as the Special Products Div. NTH develops zirconium alloy thin-wall tubing and components for nuclear reactors. . . . *Genesco Technology Corp., Los Angeles, has purchased the assets of the Pacific Coast Magnetics Operation of Dresser Industries' HST Div., Northridge, Calif. The transaction involves all assets, including the inventory and equipment of the Pacific Coast HST Div.* . . . Heli-Coil Corp. of Danbury, Conn., has signed an agreement to acquire the assets and business of Kenyon Instrument Corp., Guilford, Conn. Kenyon Instruments makes hydraulic and pneumatic controls and regulators, primarily for the aerospace industry. . . . *GCA Corp., Bedford, Mass., has signed a final agreement to purchase Precision Scientific Co. of Chicago (M/R, May 10, p. 41). PS manufactures laboratory apparatus and analytical instruments.*

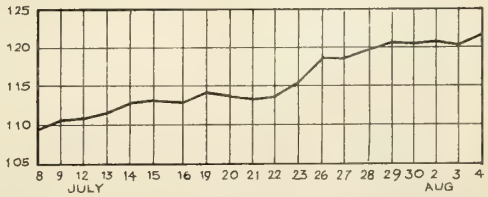
New Activities

The Boeing Co., Seattle, has formed within its framework an Aerospace Group with separate operating divisions for missile and space activities. Boeing president Willam M. Allen said of the move, "The diversity and nationwide scope of our aerospace activities make it desirable to create a corporate-level organization with distinct divisions for missile and space programs." Heading the new Aerospace Group will be Lysle A. Wood, company vice president. Vice president George H. Stoner will serve as general manager of the Space Div.; vice president E. H. Boullioun, for the Missile Div. . . . *Minnesota Aerospace Corp. has been formed in Anoka, Minn., by LeRoy A. Bushnay to produce inflatable and expandable structures for atmospheric and space applications. The firm will also conduct research and development programs in these fields.* . . . The General Electric Co. plans to combine its Research Laboratory and Advanced Technology Laboratories in Schenectady, N.Y., into a single GE Research and Development Center. . . . *Cornell Aeronautical Laboratory has formed a new systems analysis branch within its Washington (D.C.) Projects Dept. Within the branch are to be two groups, a weapons systems section and an electronics systems section. Past research conducted at CAL's Washington Projects Dept. included systems analysis, systems test design and requirements and feasibility studies. Purpose of the expansion is to enlarge WPD's role in CAL's growing research activities.* . . . CIBA Corp., Summit, N.J., has established a new Rare Metals Dept. to distribute and provide technical services in connection with titanium and columbium products the firm will import from its parent firm, CIBA Ltd., in Switzerland. . . . *Victor Equipment Co.'s Controls Div. has moved to new facilities at 2336 Auburn Ave., Sacramento, Calif. The plant doubles production capabilities. The division also maintains a fluid control research and development laboratory in Sacramento.*

Facility Expansions

A $1-million liquid-production facility will be installed at Chemetron Corp.'s National Cylinder Gas Div. in Dallas, Tex. The addition will increase the plant's production capacity from 120 tons to more than 220 tons per day of high-purity oxygen, nitrogen and argon. Operation is scheduled for early next year. . . . *Texas A&M University, College Station, Texas, has started construction of a $1.9 million space research center and data processing center. Prime designer is Bernard Johnson Engineers, Inc., Houston. Financial assistance is being provided by NASA and the National Science Foundation.* . . . Computer Text Corp., Cherry Hill, N.J., manufacturer of magnetic test equipment, has acquired 5,000 sq. ft. of space in the Cherry Hill Industrial Center. The addition will be used for production wiring and assembly of subsystem modules and components. . . . *Fairchild Semiconductor Div. of Fairchild Camera & Instrument Corp. plans to establish a transistor assembly operation at the Shiprock, N.M., Navajo Reservation* . . . Astro Technology Corp., a former subsidiary of Page Communications Engineers, Inc., on Aug. 2 moved from Palo Alto to larger facilities in Mountain View, Calif. At the same time, ATC became a division of Page.

Missile/Space Stock Index



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Publishing Date: September 6, 1965 **Advertising Closes: August 23, 1965**

Missiles and Rockets The Weekly of Advanced Technology

contracts

AIR FORCE

$6,510,349—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for work on space programs.

$6,500,000—**The Boeing Co.,** Seattle, initial installment to a $70-million contract to design and test missile trajectory prediction systems and related equipment.

$3,494,000—**Martin Marietta Corp.,** Baltimore, to design, develop, fabricate and flight-test a maneuverable re-entry vehicle.

$2,851,000—**The Boeing Co.,** Rapid City, S.D., to modify *Minuteman* missiles.

$2,420,000—**Battelle Memorial Institute,** Coumbus, Ohio, for work on a classified project.

$2,216,814—**Goodyear Tire & Rubber Co.,** Akron, Ohio, initial increment on $4-million contract for reconnaissance equipment.

$1,692,384—**Philco Corp.,** Willow Grove, Pa., for data processing equipment.

$1,300,000—**Cook Electric Co.,** Tech-Center Div., Morton Grove, Ill., for production of direction finding-tracker systems for use in *Gemini* and *Apollo* programs.

$1,000,000—**Sperry Rand Corp.,** St. Paul, Minn., to provide digital computers for guidance systems.

$270,991—**Milgo Electronic Corp,** Miami, Fla., for target designation and acquisition data equipment for Eastern Test Range telemetry antennas.

$248,520—**Rocket Power, Inc.,** Mesa, Ariz., for solid-propellant rocket motor with igniter.

$204,000—**Cosmodyne Corp.,** New York City, for modification of rocket transporters.

$165,000—**Bausch & Lomb, Inc.,** Rochester, N.Y., for design of accessory equipment for inertial component and system test table.

$157,700—**Space General Corp.,** El Monte, Calif., for micrometeorite sampling payloads and field launch services.

$150,000—**General Electric Co.,** Santa Barbara, Calif., for nuclear interference studies.

$150,000—**Servo Corp. of America,** Servodynamic Div., Hicksville, N.Y., for manufacture of microwave sweep oscillators.

$147,403—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., for research on instrumentation required for operation of 120-in. shock tunnel.

$135,000—**Sperry Rand Corp.,** Sperry Piedmont Co., Charlottesville, Va., for model of satellite operation/network control center.

$107,794—**Sperry Rand Corp.,** Sperry Gyroscope Co., Great Neck, N.Y., for attenuator systems.

$80,000—**Union Carbide Corp.,** Linde Div., Tonawanda, N.Y., for exploratory development of superconducting energy storage system.

$74,310—**General Telephone & Electronics Corp.,** Sylvania Electric Products, Inc., Waltham, Mass., additional funds to continue study of communications black-out encountered by space vehicles when re-entering the Earth's atmosphere.

$70,269—**Technoolgy, Inc.,** Dayton, Ohio, for research directed toward the automation of data reduction techniques used in airborne gravity measurement.

$64,988—**Atlantic Research Corp.,** Alexandria, Va., for research investigation of tungsten alloys for solid-propellant rocket nozzles.

$60,000—**TRW, Inc.,** Systems Group, Redondo Beach, Calif., for Snapoodle demonstration design study.

$39,885—**Nuclide Corp.,** State College, Pa., for research directed toward development of a double mass spectrometer system.

$36,500—**Litton Industries, Inc.,** Litton Systems Div., Guidance and Control Systems Div., Woodland Hills, Calif., for computer program for guidance and control systems error analysis of air-to-surface missiles.

$28,204—**Utah State University,** Logan, Utah, for engineering regarding calibration of radiometric and spectral instrumentation system for installation on space vehicles.

ARMY

$3,081,524—**Thiokol Chemical Corp.,** Marshall, Tex., to provide repair parts for missiles.

$1,663,032—**American Telephone & Telegraph Co., Western Electric Co.,** Burlington, N.C., to make repair parts for *Nike-Hercules* missiles.

$1,199,883—**Booz-Allen Applied Research, Inc.,** Bethesda, Md., for study and analysis of how the Army of the future should be organized.

$860,000—**Beech Aircraft Corp.,** Wichita, Kan., for continued support for target missile operations.

$419,492—**Raytheon Co.,** Andover, Mass., for repair parts for the *Hawk* missile system.

$263,900—**EBCO Construction Co.,** Houston, for range instrumentation for *Sprint* at White Sands Missile Range, N.M.

$246,757—**Handling Services, Inc.,** Englewood, Colo., for Army data retrieval engineering system items and services.

$80,175—**Hughes Aircraft Co.,** Culver City, Calif., for laser system integration study.

$30,000—**General Dynamics Corp.,** Pomona, Calif., for *Redeye* engineering services.

NAVY

$40,568,975—**General Dynamics Corp.,** Groton, Conn., for overhaul of nuclear vessels.

$23,597,250—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for engineering services associated with the *Polaris A-3* missile.

$14,358,645—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for work on *Polaris* missile system.

$9,934,000—**Honeywell, Inc.,** Minneapolis, and **TRW, Inc.,** Cleveland, to establish a second production source for advanced version of the Mk 46 anti-submarine killer torpedo.

$2,000,000—**Lockheed Aircraft Corp.,** Lockheed-California Co., Burbank, Calif., for underwater acoustics research to improve submarine detection.

$1,838,857—**American Telephone & Telegraph Co.,** Western Electric Co., Whippany, N.J., for oceanographic research.

$894,000—**Interstate Electronics Corp.,** Anaheim, Calif., for continued work on the *Polaris* program.

$615,368—**IIT Research Institute,** Chicago, for research and development in the field of countercountermeasures.

$508,198—**Northern Ordnance,** Minneapolis, for design, development, fabrication and supply of guided missile launching system Mk 22 train-hoist drive and control training system.

$378,362—**Honeywell, Inc.,** West Covina, Calif., for *Asroc* weapon system development program.

$300,000—**North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., for reliability program for Mk 2 SINS.

$281,397—**Hughes Aircraft Co.,** Culver City, Calif., for a developmental model of an electronic scanning antenna.

$223,000—**Philco Corp.,** Sierra Operations/Communications and Electronics Div., Menlo Park, Calif., for delivery of a transportable 500-kw communications amplifier.

$130,000—**Applied Technology, Inc.,** Palo Alto, Calif., for development, fabrication and delivery of two microwave power amplifiers for the U.S. Naval Missile Center, Point Mugu, Calif.

$110,000—**Louis Allis Co.,** Milwaukee, for experimental breadboard model missile launcher and gun mount drive system.

$92,337—**Raytheon Co.,** Lexington, Mass., for *Sparrow III* product improvement program.

$92,000—**Informatics, Inc.,** Sherman Oaks, Calif., for development of peripheral site computer programs at the Pacific Missile Range.

$82,377—**Hoffman Electronics Corp.,** Semiconductor Div., El Monte, Calif., for silicon solar cells.

$79,000—**ARINC Research Corp.,** Washington, D.C., for assessment of missile control system reliability and maintainability.

$60,500—**Sperry Rand Corp.,** Long Island City, N.Y., for development, test and evaluation of experimental pointing and firing cutout device for guided missile launching systems.

Lear Siegler, Inc., Grand Rapids, Mich., for development of a laser to be used as an illumination source for high-speed photography of ballistics range models (amount not disclosed).

NASA

$2,000,000—**Electro-Mechanical Research, Inc.,** College Park, Md., to provide research and development support for Goddard Space Flight Center's Spacecraft Technology Div.

$1,250,000—**Ling-Temco-Vought, Inc.,** Dallas, for services and materials support services for the *Scout* program.

$1,040,691—**Allis-Chalmers Manufacturing Co.,** Milwaukee, for development of a fuel cell for use in the *Apollo* program.

$790,000—**Electro-Mechanical Research, Inc.,** Sarasota, Fla., for 437 Model 287 pulse-averaging FM subcarrier discriminators.

$606,841—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., to provide 10-mw arc heaters for Manned Spacecraft Center for use in the testing of thermal protection systems and materials for manned spacecraft.

$604,000—**Melpar, Inc.,** Falls Church, Va., for research, development and supply of food required for Project *Apollo*.

$500,000—**Avco Corp., Wilmington,** Mass., for studies of conceptual design and qualification procedures for a Mars probe lander.

$424,625—**North American Aviation, Inc.,** Rocketdyne Div., Canoga Park, Calif., for continuation of a study of chamber technology for space-storable propellants.

$197,000—**Marquardt Corp.,** Van Nuys, Calif., for *Apollo* SM/RCS engine injector.

$162,594—**Westinghouse Electric Corp.,** Pittsburgh, for study of emplaced lunar scientific station, *Apollo* Extension Systems.

$120,000—**Douglas Aircraft Co., Inc.,** Missile & Space Systems Div., Santa Monica, Calif, for integration of a copyrighted computer program into life support systems design to be used at the Manned Spacecraft Center.

$119,015—**Consolidated Electrodynamics Corp.,** Pasadena, Calif., for high-resolution mass spectrometer.

$99,900—**Emerson Electric Manufacturing Co.,** St. Louis, Mo., for fabrication, customization and qualification of a dual-ablation sensor for advanced flight vehicles.

$95,000—**Lckheed Aircraft Corp.,** Lockheed-Georgia Co., Marietta, Ga., for design and fabrciation of six hydrogen quality gas measuring meters.

$86,000—**Avco Corp.,** Tulsa, Okla., for examination of various kinds of glasses in a space environment simulation chamber to determine what effect ultraviolet radiation has on the color.

$83,963—**General American Transportation Corp.,** Niles, Ill., for research and development of an advanced concept of laboratory-type oxygen reclamation systems for manned spacecraft.

$81,000—**Philco Corp.,** Western Development Laboratories Div., Palo Alto, Calif., for design definition study of instrumentation of a space flight guidance research facility at Ames Research Center.

$80,869—**National Engineering Science Co.,** Pasadena, Calif., for feasibility study of a large rocket recovery.

$79,513—**Douglas Aircraft Co., Inc.,** Santa Monica, Calif., to determine whether hybrid and high-energy solid motors will be practical for use on upper stages of future medium launch vehicles.

$73,000—**MVR Corp.,** San Francisco, for Videodisc recorders.

$60,000—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., continuation of a contract to study thermal and electrical conductivity properties of gases under high temperatures.

INDUSTRY

$3,500,000—**Collins Radio Co.,** Dallas, from **Remmert-Werner, Inc.,** St. Louis, Mo., for airborne communication and navigation systems.

$2,000,000—**Barnes Engineering Corp.,** Stamford, Conn., from **Lockheed Aircraft Corp.,** Missiles & Space Co., Sunnyvale, Calif., for Model II-C horizon sensors for use in space vehicles.

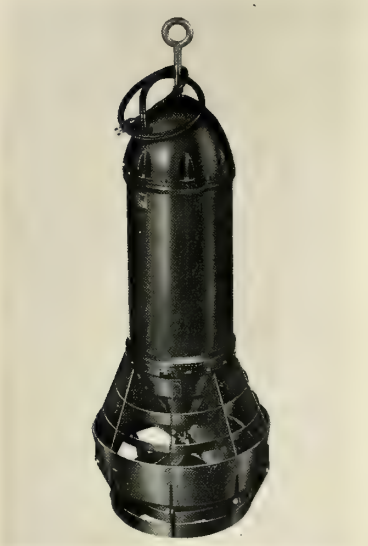
$600,000—**Bell Aerospace Corp.,** Bell Aerosystems Co., Buffalo, N.Y., from **United Aircraft Corporate Systems Center,** Farmington, Conn., for supply of accelerometers for the abort guidance system in the LEM.

$25,312—**Kollmorgen Corp.,** Inland Motor Corp., Radford, Va., from **Bell Aerospace Corp.,** Bell Aerosystems Co., Buffalo, N.Y., for direct-drive torque motors for use in the XM-58 sighting device for the *SS-11* antitank missile.

Clary Corp., San Gabriel, Calif., from **Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for production of tooling and test equipment and gyroscopes for use on the *Shillelagh* missile program (amount not disclosed).

Lockheed Aircraft Corp., Lockheed Aircraft Service Co., Ontario, Calif., from **Collins Radio Co.,** Dallas, for a 4-month project definition phase contract for aircraft modification of the *Apollo* Range Instrumented Aircraft program (amount not disclosed).

New Product of the Week: Deep-Submergence Motor



An electric induction motor, designed for applications at pressures up to 10,000 psi in fresh or sea water, has been developed by Electro-Kinetics Corp.

The 10-hp a-c unit is oil-filled and pressure-equalized, but is capable of operation should the oil filling drain out and be replaced by sea water, the firm says. For propulsion applications, the motor shaft and structure can support a fixed-pitch propeller and combination guard/nozzle.

General specifications are 10 hp, 1,100 rpm, 480 to 240v at 60 cps, 3-phase; weight is 185 lbs. in air and 150 lbs. in water. With propeller and nozzle, ahead thrust is approximately 400 lbs. at full power. Overall length is 36 in.; motor diameter is approximately 9 in.

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With PhD. or Sc.D. and several years of research experience to evaluate applied research results in physics, electronics, and mathematics. No laboratory work is involved. A broad knowledge of physics and electronics and their applications is required. Systems experience desirable.

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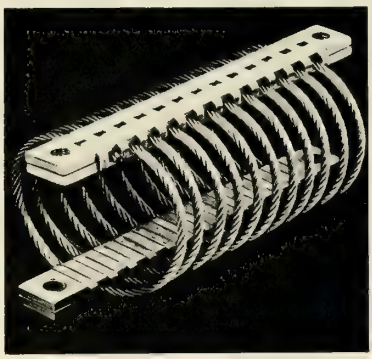


Helical Cable Isolator

A helical cable isolator, recommended for use where multi-directional performance is required, has been developed by Aeroflex Laboratories, Inc.

The device is available in three cable diameters—1/16, 3/32 and ⅛ in. It is capable of providing shock and vibration protection to masses as small as 4 oz. or as large as 2,500 lbs. It gives the same isolation as the company's straight-line isolators, but is smaller and lighter.

The unit's ability to isolate vibration while under acceleration makes it particularly suited for missile and aerospace applications, the firm says.

Circle No. 152 on Subscriber Service Card

Cryostat

A cryostat, designed to cool infrared detectors to 22°K, is being marketed by Santa Barbara Research Center.

The open-loop device utilizes water-pumped nitrogen and extra-dry hydrogen gas. Minimum operating time per standard gas cylinder is approximately 8 hrs.

Circle No. 153 on Subscriber Service Card

Programmer

A chromatographic programmer which provides on-stream control and monitoring capabilities in a single instrument without modification is available from Beckman Instruments, Inc.'s Scientific and Process Instruments Div.

The unit is capable of monitoring a single stream for up to six components. It can simultaneously provide output for control of up to three of these components.

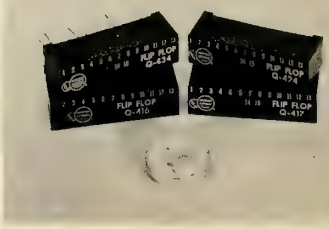
Circle No. 154 on Subscriber Service Card

Tuning Fork

A subminiature tuning fork with a frequency range of 800 to 10,000 cps is available from The Gyrex Corp.

The Model 264 is designed to withstand severe force environments without change in calibration. Operating temperature range is —55° to 100°C; operating life is 10,000 hours minimum. The unit measures 3/8 in. in diameter and 1⅞ in. long.

Circle No. 155 on Subscriber Service Card



Q-Series Flip-Flops

Engineered Electronics Co. has introduced a group of four Q-series flip flops, capable of performing as an RS, JK, trigger, gated or shift register flip flop.

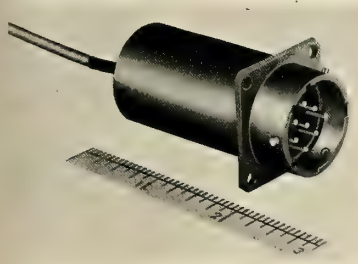
The self-contained units are available in three frequencies—25 kc clamped or unclamped, 100 kc clamped and 1 mc clamped. Power requirements are ±12v dc. Dimensions are 0.5 x 0.725 x 2 in.

Circle No. 156 on Subscriber Service Card

Compensator

A thermocouple reference junction compensator, designed to meet military specifications for launch vehicles and missile applications, is being marketed by Consolidated Ohmic Devices, Inc.

The Model JR 197 is a solid-state unit that withstands corrosive atmospheres of UDMH and nitrogen tetroxide. The 60-gram unit is accurate to ±1% from 0 to 200°F. It can withstand vibration to 30 g's, 30 to 2,000 cps, and shock to 100 g's for 10 to 12 millisecs. Sinusoidal and random vibration also meet MIL specifications.



The unit is operable in 100% humidity conditions at altitudes to 250,000 ft. Acoustic noise level is 160 db. Maximum power requirement is 1.0 milliwatt with input voltage of 2.000v dc ±0.5% and output impedance of 220 ohms maximum.

Circle No. 157 on Subscriber Service Card

Signal Conditioner

Electronic Modules, Inc., is marketing a miniature signal conditioner. The solid-state unit consists of a dc/dc converter, a precision 5 to 50-v regulator and a differential amplifier. The 4-oz. device measures 1.5 in. long and 0.95 in. in diameter.

A delta gain-excitation product of 0.005%/°F is available. Standard units offer a delta g-e product of 0.02%/°F over a temperature range of —65° to 250°F.

Circle No. 158 on Subscriber Service Card

Circulation Heater

A thermostat-controlled circulation heater for cryogenic systems has been developed by Vulcan Electric.

The system, designated ACH, heats nitrogen gas from —400°F to predetermined set points between —100° and 700°F with a sensitivity of ±2°F. The stainless steel device consists of tubular heating elements, a Vulcan Cal-Stat thermostat and insulated chamber. It is also available for heating oil, water, steam and air.

Circle No. 159 on Subscriber Service Card

Waveguide Termination

A line of temperature-controlled waveguide terminations in a frequency range of 5.85 to 90 gc is being marketed by MCS Corp.

Units are of a broadband design, each covering the full waveguide bandwidth. Temperature of each unit is maintained by an oven to an accuracy of ±0.1°C for extended periods of time. Temperature ranges available are between 40° and 100°C. Termination VSWR's are less than 1.02. Power input requirements are nominally 10-15 watts, 115v, 60 or 400 cycle.

Circle No. 160 on Subscriber Service Card

Data Modem

A microminiature data modem, specifically designed to utilize monolithic integrated circuits, has been developed by Electronic Communications, Inc.

The unit is a modular-demodulator, which accepts digital data and modulates it into a form for transmission over a voice communication channel. The process is reversed at the receiving end. The device is capable of operation at 1,300 bits/second, 2-phase; 2,600 bits/second, 4-phase, and is adaptable to military or non-military packages.

The device can be packaged in 2 to 4 cu. in. and requires less than 2.5 watts d-c power.

Circle No. 161 on Subscriber Service Card

Spectral Sensing Unit

A portable spectral sensing unit, having all the characteristics and similarities of a spectrophotometer, has been designed by Schoeffel Instrument Co.

The M-600 consists of a quartz prism monochromator attached to a photomultiplier sensor. The unit can detect radiation in the electromagnetic spectrum range between 185 and 1,500 millimicrons. Resolution is 0.26 mu at 200 mu, 3.2 mu at 400 mu and approximately 10 mu at 700 mu with a slit width setting of 0.1 millimeter. The bandwidth to be intercepted can be adjusted by an in-unison operating slit-width control.

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DYNAMIC ANALYSTS for MISSILE SYSTEMS

The Advanced Projects Laboratories of our Aeronautical Systems Division has several openings for Dynamic Analysts for Missile Systems.

The assignments will involve the analysis of tracking and autopilot systems for air-to-air and air-to-ground missiles, the preliminary design of new missile systems and the establishment of functional requirements for equipment designers. A typical problem would be to specify autopilot configuration for high-speed, long-range air-to-air missiles in the presence of noise and varying aerodynamic environments.

The positions require experience in linear or non-linear control theory, rigid body dynamics, inertial devices, noise theory and the use of analog and digital computers. An accredited degree in E.E. is required.

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SENDERS

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John W. Senders: Appointed a principal scientist of Bolt Beranek and Newman, Inc. This position is equivalent in stature to that of a corporate officer and recognizes one who has achieved a distinguished record of scientific performance and who is a nationally acknowledged leader in his field. He is a contributor to research in manual control of space vehicles.

Richard F. Cottrell: Appointed manager of Aerojet-General Corp.'s Solid Rocket Operations. He has been personally directing the development of the 260-in. solid rocket motor for NASA at Aerojet.

Dr. Frank N. Gillette: Appointed director, research and advanced development, at GPL Div. of General Precision, Inc.

Byron P. Gardner: Appointed operations planning manager of the Houston Operations of Philco Corp.'s Western Development Labs. Also named to a new position in the division was **George J. Pastor** who was appointed manager of the Display Systems Dept.

Dr. Eugene C. Huebschman: Named chief scientist of the Earth Science Div. of Teledyne Corp.

Patrick S. Parker: Named president of Parker Seal Co. Div., Parker-Hannifin Corp. He was formerly manager of the Aerospace Components Div. of Parker Aircraft. Also named to a new position was **W. G. Webster,** director of marketing for the Aerospace group.

Four new directors have been named at IIT Research Institute. **Dr. J. I. Bregman** was appointed director of the Chemical Sciences Research Div.; **Dr. Morton J. Klein,** director of the Applied Chemistry Research Div.; **Clinton A. Stone,** director of the Astro Sciences Research Center; and **Charles W. Terrell,** director of the Physics Research Div. All were previously assistant directors of their groups.

Bastian Hello: Named director of lifting body programs with responsibility for maneuverable re-entry spacecraft projects for Martin Co. He was previously director of the *Gemini-Titan II* launch vehicle program and will be replaced by **Walter D. Smith.**

Malcolm Smith: Elected to the board of directors of Laboratory For Electronics, Inc. He is a New York investment banker.

William G. Drechsler: Appointed vice president of Dynatronics, Inc. He will continue his responsibility as manager of the company's *Apollo* PCM telemetry program.

Dr. Robert M. Healy: Appointed director, materials and components research, of Amphenol Corp. He will also be responsible for directing the activities of the Ceramic Pilot Plant Operation.

Paul L. Shultz: Appointed director of engineering for the R. J. Enstrom Corp.

Dr. Richard A. Stasior: Named manager of applications engineering for the Syracuse unit of General Electric's Semiconductor Products Dept. **Donald E. Uren** has been named manager of engineering for GE's Heavy Military Electronics Dept.

Dr. Ralph D. Bennett: Named vice president-research at Martin Co. He was previously director of research and vice president in charge of the company's nuclear programs at Baltimore.

Hugo V. Lizza: Elected president and general manager of Bermite Powder Co. He succeeds his father, the late **Patrick Lizza,** founder and president of the company.

Dr. Elliot Berman: Named to the newly-created post of director of Itek Corp.'s Lexington Research Labs. He was previously technical director of Itek's Research Div.

Franklin R. Goodman: Formed Tynax Engineering Co. to manufacture tiny coaxial connectors. He was previously assistant to the president at Microdot Inc.

Irving Roth: Named vice president and special assistant to the president in charge of international financial and economic policy relationships with the U.S. and foreign governments for Northrop Corp. **Joseph Corie** was appointed corporate vice president-government procurement policies; and **J. Grant Macdonnell** was named corporate vice president and corporate controller. **Jack T. Bradley,** director of international service of the Aerospace Industries Assn., has been appointed a vice president of Northrop's International Div.

when and where

AUGUST

Eighth National Heat Transfer Conference, sponsored by American Society of Mechanical Engineers and American Institute of Chemical Engineers, Biltmore Hotel, Los Angeles, Aug. 8-11.

Tenth Technical Symposium, sponsored by Society of Photo-optical Instrumentation Engineers and Air Force Systems Command, Jack Tar Hotel, San Francisco, Aug. 16-20.

1965 National Meeting of the American Astronautical Society, Sheraton Palace, San Francisco, Aug. 18-20.

International Conference on Energetics, sponsored by ASME, University of Rochester, Rochester, N.Y., Aug. 18-20.

International Lunar Geological Field Conference, sponsored by University of Oregon and New York Academy of Sciences, Bend, Ore., Aug. 22-28.

Sixth International Electronic Circuit Packaging Symposium, sponsored by Electrical Design News (concurrent with WESCON), San Francisco Hilton Hotel, San Francisco, Aug. 23-24.

Cryogenic Engineering Conference, sponsored by Cryogenic Society of America, Rice University, Houston, Aug. 23-26.

Conference on the Exploration of Mars and Venus, sponsored by Virginia Polytechnic Institute, NASA and Air Force Cambridge Research Laboratory, Blacksburg, Va., Aug. 23-27.

1965 Western Electronic Show and Convention (WESCON), San Francisco, Aug. 24-27.

Annual Conference on Applications of X-ray Analysis, sponsored by Denver Research Institute, University of Denver, Albany Hotel, Aug. 25-27.

1965 International Symposium on Antennas and Propagation, sponsored by Institute of Electrical and Electronics Engineers, Sheraton Park Hotel, Washington, D.C., Aug. 30-Sept. 1.

Twelfth National Conference of the Armed Forces Management Assn., Washington Hilton Hotel, Washington, D.C., Aug. 31-Sept. 2.

SEPTEMBER

Second Annual Conference on the Effects of Shock and Vibration on the Human Body, sponsored by University of Denver and the Colorado Chapter of the Institute of Environmental Sciences, University of Denver, Denver, Sept. 1-3.

URSI Symposium on Electromagnetic Wave Theory, sponsored by U.S. National Committee, International Scientific Radio Union (URSI), Technological University of Delft, The Netherlands, Sept. 6-11.

XVIth International Astronautical Congress, sponsored by the International Astronautical Federation, Athens, Greece, Sept. 12-18.

Thirteenth Annual Joint Engineering Management Conference, sponsored by American Institute of Aeronautics and Astronautics, Institute of Electrical and Electronics Engineers, ASME, and others, Roosevelt Hotel, New York City, Sept. 13-14.

Thermophysics Specialist Conference, sponsored by American Institute of Aeronautics and Astronautics, U.S. Naval Postgraduate School, Monterey, Calif., Sept. 13-15.

Electrical Insulation Conference sponsored by U.S. Navy Bureau of Ships and Allis-Chalmers Mfg. Co., New York Hilton, New York City, Sept. 13-16.

Symposium on Structural Adhesives Bonding, sponsored by Picatinny Arsenal (U.S. Army Munitions Command), Stevens Institute of Technology, Hoboken, N.J., Sept. 14-16.

Advanced Incentive Contracting, sponsored by National Defense Education Institute, Washington, D.C., Sept. 15-17.

Astrodynamics Specialist Conference, sponsored by AIAA and ION, U.S. Naval Postgraduate School, Monterey, Calif., Sept. 16-17.

National Power Conference sponsored by IEEE and ASME, Sheraton-Ten Eyck Hotel, Albany, N.Y., Sept. 19-22.

Fifth Annual National Conference on Environmental Effects on Aircraft and Propulsion Systems sponsored by U.S. Naval Air Turbine Test Station, Nassau Inn, Princeton, N.J., Sept. 20-22.

Systems Engineering Exposition and Conference McCormick Place, Chicago, Sept. 20-23.

International Conference on Thermionic Electrical Power Generation, sponsored by Institution of Electrical Engineers, London, Sept. 20-24.

Advanced Incentive Contracting, sponsored by NDEI, Los Angeles, Sept. 21-23.

Fifth Annual Bio-Environmental Engineering Symposium, sponsored by the USAF School of Aerospace Medicine, Brooks AFB, Tex., Sept. 21-24.

1965 IEEE Conference on Military Electronics (MIL-E-CON 9), Washington Hilton Hotel, Washington, D.C., Sept. 22-24.

13th Annual Communications Conference, sponsored by IEEE, Cedar Rapids, Iowa, Sept. 24-25.

Advanced Incentive Contracting, sponsored by NDEI, New York City, Sept. 28-30.
Second Internatioinal Congress on Experimental Mechanics, sponsored by Society for Experimental Stress Analysis, International Inn, Washington, D.C., Sept. 28-Oct. 1.

1965 Fall National Symposium of the Society for Information Display Commodore Hotel, New York City, Sept. 29-30.

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No Time for Civilians

SECRETARY OF DEFENSE McNAMARA is approaching a deployment decision on the *Nike-X* ballistic missile system in an atmosphere befogged with Army optimism, clouded by unnecessary military security and misted over by public misunderstanding.

There now seems to be general agreement that the *Nike-X* system technically is ready for a go- ahead on deployment. After several years of alternating high hope and disappointment, the Army is more confident than ever that the budget decision this fall will be in favor of deployment of the *Nike* system in some form.

Much of this optimism stems from the fact that the spectre of unsophisticated nuclear-tipped missiles in the hands of the Red Chinese suggests that a limited version of *Nike-X* be deployed to meet the threat.

This so-called Light Attack Defense Model to counter the menace from the Far East would cost $5-8 billion over a five-year period. This obviously is more palatable to the economy-minded Defense Secretary than the $20-billion pricetag for a system capable of countering the presumably more sophisticated Soviet threat.

If one may say so, the Army seems almost delighted that the Chinese are providing a *raison d'être* for the bargain-basement *Nike* system. It is true, of course, that the less expensive version of the *Nike-X* is capaple of building-block expansion into a system capable of handling a sophisticated threat.

This seems to us, however, to be begging the issue. Has the Soviet threat suddenly disappeared? Or is it that we now trust the Soviets to exercise some discretion in the use of nuclear power while the Chinese are regarded as trigger-happy in this regard? If so, then we are making once again the old mistake of arming to meet what we believe to be the enemy's intentions rather than his capabilities.

If we need *Nike-X* to counter the not-yet-existent Chinese capability, then do we not just as certainly need it to meet the existing Soviet capability? The answer obviously is yes. It is equally obvious that talk of the danger from unsophisticated Chinse missiles is an attempt to sugar-coat the multi-billion-dollar pill. For whom, Mr. McNamara or the general public? Probably both and in that order.

The cheaper approach to *Nike-X* deployment also has another advantage. Deployment of the "poor man's" model reduces the importance of an expensive and alarming civil defense shelter effort.

Obviously, if the plan is to worry about only a few Chinese missiles then there is no need to undertake a vast program of shelter protection against the Russian missiles. We thus proceed on the dangerous assumptions that Chinese missiles will be few and unsophisticated and that the much more threatening Soviet power can be ignored because it will not be employed. Why? Perhaps for three reasons. First, it enables start on production of a ballistic missile defense pointedly deployed only against the Chinese and without a widespread civil shelter program. This approach is the least destabilizing to the hoped-for U.S.-Soviet *détente*. Secondly, should the *détente* not develop, it provides the basis for rapid upgrading of a system already emplaced. And thirdly, it is the most palatable if weak-kneed approach for an Administration which certainly doesn't want to rock the political foundations of the Great Society by financing and building civil defense shelters across the land.

WE RAISE THESE QUESTIONS and alternatives because perhaps the worst aspect of the whole affair is the cloak of deception wrapped around the subject, not to conceal legitimate military secrets but to hide the pros and cons while the decision is made.

We feel that the public has the right to know the various alternatives involved in the decision faced by Mr. McNamara. We feel this because we see no reason to assume that the American citizen would not be willing to assume the burden of a $20-billion *Nike-X* and shelter system if he understood that it might save 80 million lives.

Certainly, he cannot at this moment reach an intelligent decision—if we are to credit a yet-to-be-released survey which shows that two-thirds of the American people believe that the U.S. already has a ballistic missile defense system in operation. This is a shocking indictment of the Administration's lack of frankness on the subject.

The 126-page study, dated Sept. 30, 1964, and entitled "Public Opinion and Ballistic Missile Defense" is locked away in Pentagon files. The survey was carried out for the Office of Civil Defense by the TEMPO division of General Electric, Santa Barbara, Calif.

The statement on its cover reads:

"Not for public release. This document not approved for open publication nor for distribution to the Office of Technical Services, Department of Commerce. Qualified requestors may obtain copies from the Defense Documentation Center."

In our view, every U.S. citizen should be a highly "qualified requestor" of this document. It would be one more fact in his meager store of facts concerning the vitally important decision confronting the Secretary of Defense.

Our society was founded and flourished on the premise that controversy and its attendant discussion and compromise are the life-blood of democracy. Yet controversy now seems to be a nasty word and a preoccupation with "consensus" dictates the sort of close-to-the-vest maneuvers currently associated with *Nike-X* at the Administration level.

We favor a return to the theory that the citizen is entitled to know not only the decisions of his government but the factors and considerations involved in reaching those decisions.

William J. Coughlin

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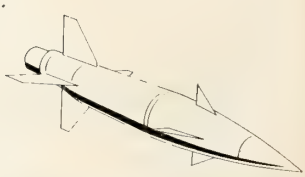

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THE WEEKLY OF ADVANCED TECHNOLOGY

HOUSTON PUBLIC

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AC-6 Success Aids Surveyor

New Lifting Body Proposal

Public Uninformed On A-ICBM's

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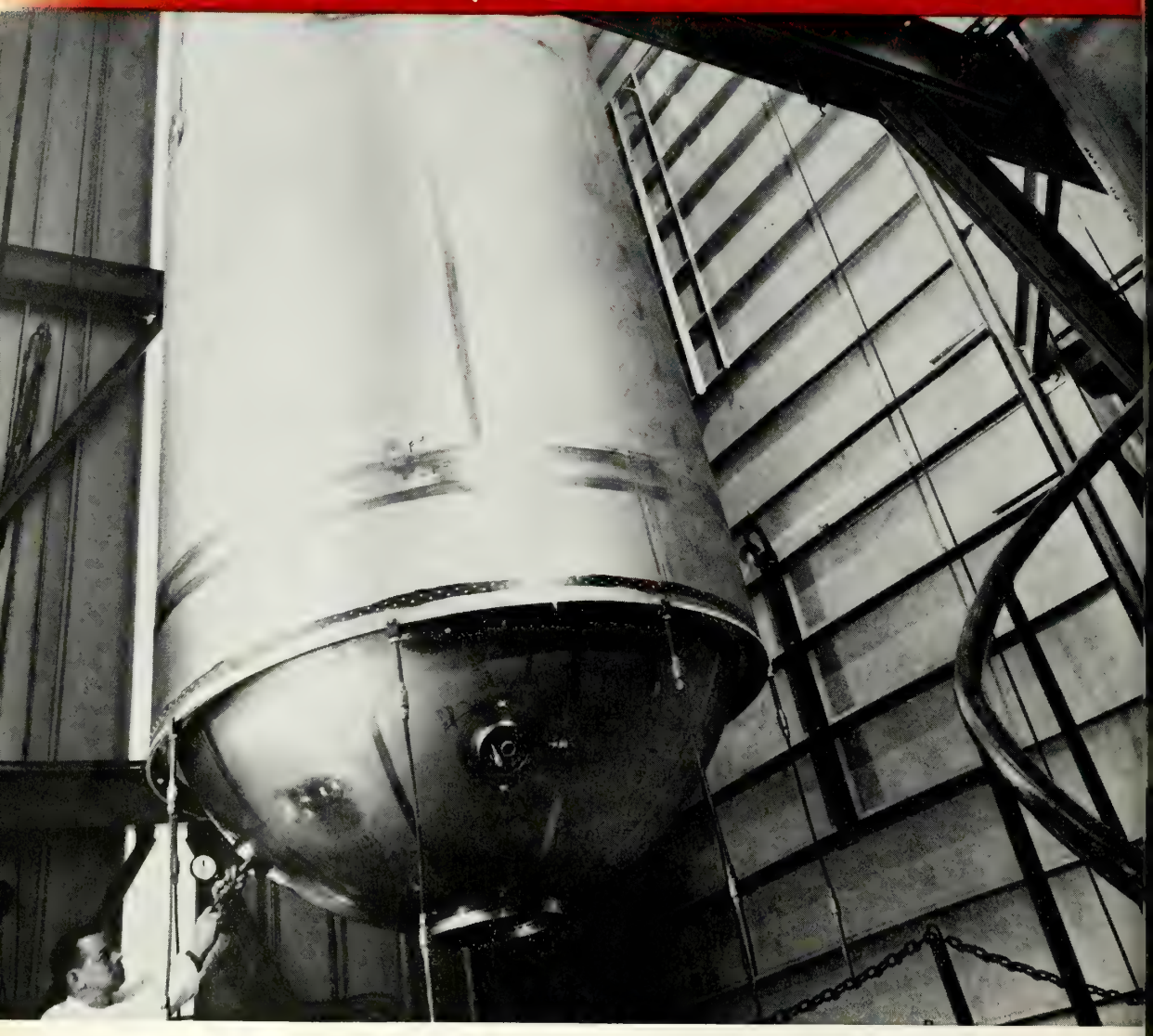

Beech works wonders with titanium to save weight . . . increase space payloads

Largest titanium structure ever built, and Beech built it.

The large tank in this picture is made entirely of titanium. Built by metal-working experts at Beech to hold 7,000 gallons of pressurized liquid hydrogen, the tank is eight feet in diameter and 24 feet long. Weight savings are tremendous.

This means more payload.

Fabricating titanium is an old story at Beech. And if it's something that's never been done before, that's not unusual. In this case the upper and lower hemispherical tank heads were chemically milled in a complex pattern to extremely close tolerances. Production welding of .012″ titanium is S.O.P. at Beech. Much of the equipment used by the Aerospace Division is one-of-a-kind and must be designed and built under the most rigid controls. Other jobs make use of Beech's extensive metal bonding capabilities.

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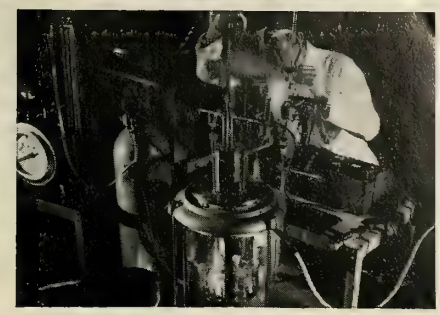

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Manufacturing...

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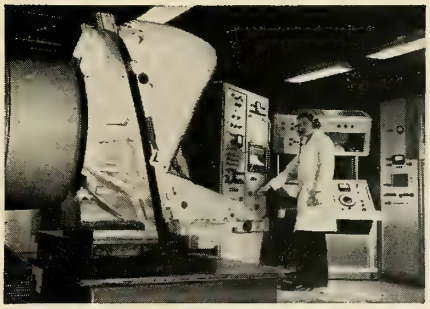

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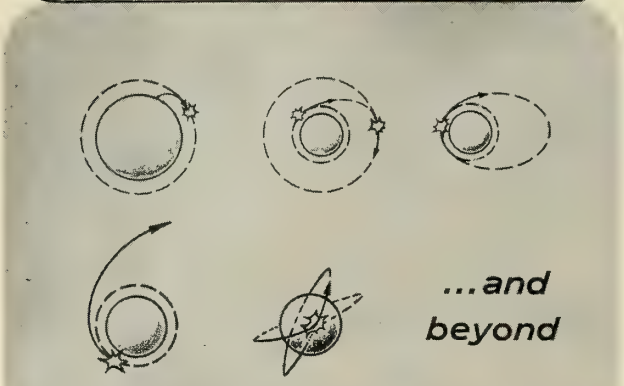

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BASE ELECTRICAL — B.S. in E.E. with 3-5 years' experience involving design of electrical power installations, electrical ground cable and missile interconnecting systems, switching and distribution units. Will develop specifications, test requirements, and analysis of flight data.

GUIDANCE AND CONTROL — B.S. in E.E. or Math with 3-5 years' experience. Assignments involve the ability to prescribe the requirements for advanced flight control and stability studies. Individuals will synthesize and analyze control systems for booster and space vehicles during ascent and in-orbit flight conditions.

STRUCTURAL AND MECHANICAL GROUND BASE DESIGN — Structural mechanical designers to work on missile ground transport and launch equipment. Experienced in fluid systems design, process piping, mechanical component design (valves, regulators, filters) or heating, ventilating, air conditioning equipment.

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STRUCTURAL DYNAMICS — Advanced degree with 5 years' senior technical experience. Performs highly complex aeroelastic, dynamic and/or load analysis or tests on an independent basis. Develop improved math models dynamic response analysis, buffet, gust and flutter.

PROPULSION — B.S. degree with 3-5 years' experience. Analysis, design and system integration of liquid and solid propellant systems. Assignments require thorough knowledge of thermodynamics, heat transfer and fluid dynamics. Experience applied to missile or space craft pressurization, propellant feed and rocket engine systems analysis. Must use existing IBM programs and set up new analytical approaches.

OPERATIONS ANALYSIS — Several senior and intermediate level positions requiring 3 to 8 years' proven aerospace experience with demonstrated modeling capability. Assignments will involve development of math models for various aspects of weapon and space systems effectiveness. Analyses will include study of existing and projected weapon and space systems via mission analysis, war-gaming, simulation, estimates of offensive and defensive force size and mixes, payload utilization and customer requirements. Applicants will have a Bachelors Degree and some advanced study.

INTELLIGENCE SPECIALIST — Will conduct critical analyses to establish intelligence parameters, effectiveness tradeoffs, determine impact on strategic offensive-defensive force requirements plus impact on future strategic weapon systems. A degree is important or 10 to 15 years' experience which is current in Stratintell, Data Acquisition, Processing, Sensor Command and Control Systems.

SPACE MISSION ANALYST — With B.S. and advanced work desirable plus 3 to 8 years' experience, will provide mission analyses of national space programs to develop trends for both launch vehicles and spacecrafts utilizing economic and technical knowledge will determine forcing functions and interactions between payload development and launch vehicle growth.

PARAMETRIC COST ANALYSIS — Economic aerospace background will be utilized to determine cost trends in large system development, procurement and operation. With historical data and technological projection, develop cost curves based on system parameters such as payload weight, pounds of vehicle, ballistic ranges, etc., that can be directly applied in cost effectiveness tradeoffs of future military and space systems. Bachelors Degree and 5 to 8 years' experience in cost analysis and economic planning.

COMPUTER PROGRAMMERS — To analyze, develop and implement business data processing applications for large scale tape oriented computer systems. IBM 7000 series experience desirable. Minimum two years' programming experience mandatory. B.A., B.S. or equivalent data processing experience required.

STRESS ANALYSIS — Utilizing computer techniques, will conduct stress analyses of airborne and ground structural and mechanical components involving large booster systems. Will plan and coordinate necessary testing. A B.S. degree and 3-5 years applicable experience is needed.

ACOUSTIC AND VIBRATION ANALYSTS — Graduate engineers, M.E. or E.E., with minimum of two years' experience on analysis and prediction of rocket and missile acoustic and vibration environments, to conduct post-flight studies on large booster systems.

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Volume 17, Number 7 August 16, 1965

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THE COVER

Support for Apollo Command Module ablative heat shield undergoing ultrasonic testing at Avco Corp.'s Research and Advanced Development Div. The testing insures that glass fiber honeycomb matrix is properly bonded to vehicle's substructure.

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Design, fabricate, test: High energy density batteries, electrodes, separators, cases, seals, components.

letters

Mariner via Laser/Audio

To the Editor:

After so many months of hard effort, it was very rewarding to see the report of our program ("Mariner Data Shared," M/R, July 19, p. 10). Perhaps, now that we all know how phenomenally well the mission went, your readers would be interested in a few highlights of the evening of encounter.

As the only museum in the Nation with a direct two-way line to Jet Propulsion Laboratory, we had first-row seats for all activity. In our Complex approximately 2,000 persons came and went as the evening wore on, between 7:00 p.m. and 1:00 a.m. July 14 and 15. As reported, we did a live radio broadcast direct from our *Mariner* Mars Complex, utilizing both the many Mars experts on hand and the reports from *Mariner* Control via our line. When Dr. Hibbs was not presenting new developments in the mission we drew upon a variety of personnel in the JPL auditorium, including Dr. Robert Richardson noted Mt. Wilson and Palomar astronomer and specialist in Martian phenomena, particularly cloud formations.

It was Dr. Richardson who, after making a special trip to the Lab just to be on our program, said "Even now, with all this activity, you find it very hard to believe it's all real." Through the efforts of many hard-working individuals, both at JPL and in Washington, there was no drop in excitement or feeling of history-in-the-making 3,000 miles across the continent.

As also reported, we are now engaged in an attempt to produce accurate color prints from the red/green overlapped regions of the *Mariner IV* photos through the generous cooperation of the inventor of the Polaroid camera, Dr. Edwin H. Land. Dr. Leighton, Dr. Land and ourselves expect to have something interesting to look at in perhaps a month's time. Anyone interested in knowing more about the Land process and the *Mariner IV* photos can address questions to the Springfield Museum of Science, 236 State Street, Springfield, Mass.

Incidentally, we would appreciate a few copies of the July 19 issue for the staff members of WWLP Television, who provided the receiving site for the first commercial laser broadcast, and those of WTIC Radio, the station over which the program was actually aired.

Finally, we would like to publicly congratulate all the NASA, JPL, and contractor members of the *Mariner* story. From our position over the past nine months, we can say that every individual connected with this project can share credit for the most spectacular and informative single spacecraft in the infant Space Age. May we have more.

Richard C. Hoagland
Curator of Astronomy and Space Science
Springfield Museum of Science
Springfield, Mass.

Outside the Window

To the Editor.

Since I am not an astrophysicist, I would like to ask you or any of your readers to help answer a few questions for me. Is it really considered implausible or disadvantageous to send a spacecraft to another planet or other parts of the solar system by using anything but the minimum-energy launch windows that are now used? Isn't it practical to have some on-board propulsion system that could be fired after the spacecraft reached escape velocity in order to significantly reduce the transit time? Would such an attempt to save time be outweighed by the disadvantage of less payload? Wouldn't the reliability of the spacecraft's experiments be increased because of less exposure to the cold of space during a shorter-time-duration trip?

Rolfe MacCullough
Springfield, Va.

In general, the answer to the first question is no; the other questions can't be answered yes or no—it depends on the mission parameters.—Ed.

Independent Research

To the Editor:

As a constant reader of MISSILES AND ROCKETS, I've noticed that you are almost slavish in your attention to big science and big engineering to the neglect of advances made by small companies or individuals.

Is it that single researchers and inventors or small groups of such people no longer exist outside of small laboratories? Or is it that they do exist and are no longer contributing as they have in the past? Or perhaps your editors and writers are so swamped with material from organizations that can afford public relations counsels that they don't know of the work done by individuals working independently?

I feel that much engineering work can be done by committee—and like a summer picnic, the more people engaged in it the merrier. But creative technical work—no!

I suggest that M/R give more attention to individual investigators.

William Hyman
Brooklyn, N.Y.

Reprints of M/R Index

Reprints of the editorial index of articles appearing in MISSILES AND ROCKETS during the first six months of 1965 are available at no cost from:

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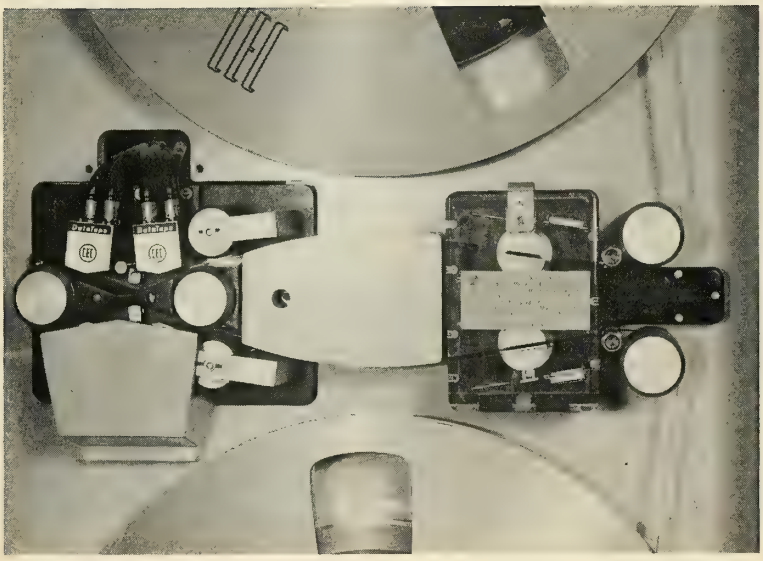
CEC's VR-3600 establishes new record for head life



It is not news that the VR-3600 is the most advanced of all magnetic tape recorder/reproducers. This has been proved in countless telemetry and laboratory applications. But what *is* news, is the remarkable durability of the instrument's recording heads.

All reports have shown that CEC's head life guarantee of 1000 hours is not only realistic but very conservative, since in virtually every case the new recording heads have surpassed this figure with little sign of wear. Compare the 1000 hour achievement with the performance of the VR-3600's closest competitor, and the savings to the user become significant indeed.

Reason behind the performance: these CEC recording heads are of a unique material and solid metal pole-tip design which completely eliminates the weaknesses of conventional head lamination or other solid-tip designs.

Result: a head that both provides superior performance at frequencies to 1.5 mc and reduces head wear and cleaning to a minimum.

Other advantages of the VR-3600 include...

1 **Bandwidth switchability.** With a mere flick of a switch, the operator may instantly change from wideband to narrow band, and back again—thus *doubling* the unit's capability with *no change* of components required. (On special order.)

2 **Constant flux recording** for assured machine-to-machine compatibility at all frequencies and tape speeds (with IRIG standards).

3 **Six speed switchable video FM**—d-c to 500 kc.

4 **Single source responsibility.** All components are designed and manufactured by CEC...including the video FM!

Important features:

◙ Pushbutton selection of *six* transport speeds along with associated electronics.

◙ Each of the VR-3600's 7 or 14 record/reproduce channels can be used for data storage in the 400 cps to 1.5 mc or d-c to 500 kc frequency range.

◙ Automatic end-of-reel sensing stops tape without leaders; transfer switch provides start command for nearby recorder and 30 second overlap of recorded data between machines—at no extra cost.

◙ IRIG or 18.24 kc AM servo system or time expansion/contraction servo system using common assemblies mean low cost for any version or combination of servo systems.

◙ Tape is constantly cleaned by optional vacuum/ionization; tension controlled, in all modes, by closed-loop servo control.

◙ Individual plug-in equalizers (6 per amplifier) meet all specifications simultaneously. Buy only those required, then set and forget.

◙ Record and reproduce amplifiers are solid state; the direct system fully amplitude- and phase-equalized.

◙ Tape transport skew is less than 0.5 μsec; complete cumulative flutter less than 0.30% p-p at 120 ips.

◙ The system may be supplied in single or dual rack configurations, with or without a dolly.

For *all* the facts about the VR-3600, call CEC or write for Bulletin 3600-X17.

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The Countdown

WASHINGTON

Russian to the Moon

Soviet sources in Washington say Russia is working as rapidly as possible on its manned lunar landing project. The same sources say the last Soviet probe revealed a deep dust layer on the lunar surface.

Congress to Probe Labor Troubles

Watch for a Congressional investigation of the entire space labor picture. There is concern on the Hill over the fact that at Cape Kennedy and the Mississippi Test Facility labor stoppages this year already have nearly equalled the entire time lost last year. Sen. John L. McClellan (D-Ark.) has had investigators for his Permanent Subcommittee on Investigations at the Cape and other NASA installations since late June.

Army Takes New Look at Air Defense

Death of *Mauler* means a whole new look at the air defense situation by the Army. Pre-program definition studies of the threat from tactical ballistic missiles and low-flying aircraft will be initiated this fall. Approach will be cautious in the hope of avoiding another $200-million project which will wind up in cancellation.

Aerospace Probe Report Due

Release of the House Armed Services Investigations Subcommittee report on Aerospace Corp. is expected within a week. According to insiders, the 100-page document pulls no punches. It already has been approved by subcommittee members. One aftermath of the probe: Aerospace has severed its relationship with the public relations firm which advised the company how to testify before the committee.

A Hoot of Owls

NASA has signed a $3.6-million contract with Rice University to supply two *Owl* satellites, together with a flyable prototype, for the *Explorer* program. First launch of the 140-lb. satellite is expected in 1967 from the Western Test Range. Booster will be a *Scout*.

A Watery Future for Gemini

Chances of a dry landing for the twelfth *Gemini* flight now appear slim. While enthusiastically pushed by Manned Spacecraft Center officials, the plan got a cool reception at NASA headquarters. Dry landing will be approved only if Project *Apollo* officials make a case for it as a requirement in their program or if Dept. of Defense requests that NASA attempt the mission.

DOD To Take Over Support Jobs

Some 8,000 jobs now under contract by the military services for technical support of weapon systems will be eliminated or replaced with Dept. of Defense in-house personnel. This means retention of about 3,000 on a contract basis. DOD officials say the move will result in considerable cost saving.

INDUSTRY

GD/Pomona Starts Layoffs

General Dynamics/Pomona is winding up layoffs resulting from the *Mauler* cancellation. Company officials say they hope final result will show a loss of only 1% or 2% of the facility's 5,500-man work force. Majority of those in the *Mauler* project are being transferred to other programs.

LTV Negotiates $50-Million Credit

Ling-Temco-Vought and its three publicly-owned subsidiaries have negotiated a $50-million revolving credit agreement with eleven U.S. banks. Company executives say the funds will be used for anticipated growth and expansion of the subsidiaries, not the parent company.

Douglas Tests Saturn Upper Stage

Douglas Aircraft carried out a successful 7½-min. preflight test firing at its Sacramento facility of the first flight upper stage for the *Saturn IB*. Test was the final full dress rehearsal before formal turnover of the S-IVB stage to NASA.

INTERNATIONAL

German ELDO Participation at Stake

This fall's elections may have an effect on the extent of Germany's role in ELDO. There is a strong feeling in some quarters that the country should pull out of the international space organization.

Spanish Flight Program Set

First rocket launches in the Spanish space research program are expected to begin next year. These will be in the 40-km. range. At a later date, launches of 180 to 300 km. height are planned. Spain also is planning a permanent launch site at Cape Ortegal, in the northwest.

Indians Plan 12 Launches from Equator

A series of 12 sounding rocket launches will be carried out by NASA and the Indian Department of Atomic Energy (DAE). The program is covered in a memorandum of understanding which extends an original U.S.-India agreement announced Jan. 14, 1963. The upper-atmosphere probes will be launched from the Thumba Equatorial Rocket Launching Station near Trivandrum.

GT-5 Launch at Hand

NASA may launch the *Gemini 5* 8-day manned space flight as early as Aug. 19.

A full-duration mission would achieve the longest manned space flight to date and give the U.S. the lead for the first time in total man-hours in orbit.

Astronaut L. Gordon Cooper, Jr., will be command pilot and Astronaut Charles Conrad, Jr., will be pilot for the mission.

The backup crew is Astronaut Neil A. Armstrong, command pilot, and Elliott M. See, pilot.

Gemini 5 will be launched by a two-stage *Titan II*, a modified Air Force ICBM, into an orbit with an apogee of 219 statute miles and a perigee of 100 mi. Each orbit will take about 90 minutes and range between 33 degrees north and south of the equator.

Flight time for *Gemini 5* will be about 191 hours and 53 minutes, during which it will complete 121 revolutions of the Earth. Landing is planned at the beginning of the 122nd revolution about 500 miles southwest of Bermuda in the West Atlantic.

Titan II Silo Work Halted

Modification of Air Force *Titan II* missile sites has been temporarily suspended pending an investigation of the disastrous fire that claimed the lives of 53 of a 55-man crew working in a silo at the Little Rock *Titan II* site, 10 mi. south of Searcy, Ark., last week.

Although the Air Force would not assign a cause for the fire, there was speculation that it was started by the explosion of diesel fuel in a tank supplying an engine for auxiliary power in the silo.

Twenty-one of the nation's 54 operational *Titan II* silos had already been reworked when the accident occurred at the Little Rock Site No. 4. None of the work related to missile equipment itself. Contractor for the operation is Peter Kiewit & Sons, Omaha, Neb.

The nuclear warhead of the missile in the silo had been removed as a safety precaution when crews began maintenance and modification work on the silo itself about a month and a half ago. Apparently the missile in the silo was undamaged and its liquid fuel did not ignite.

The disaster was the worst in the history of the United States missile program. Worst earlier mishap occurred May 22, 1958, when eight *Nike* missiles exploded at a site near Middletown, N.J., killing 10 persons and injuring three others.

Speculation that Air Force personnel operating the missile's control center had closed an escape hatch to smother the fire was flatly denied by SAC's chief of maintenance, Maj. Gen. A. J. Beck.

Shots of the Week

LTV Aerospace announced Aug. 5 that its *Lance* battlefield missile underwent the first firing from the system's self-propelled launcher on Aug. 3 at White Sands Missile Range, N.M. (picture, p. 12).

- The Navy termed the flight test of its Simplified Inertial Guidance System (SIGS) Aug. 4 "perfect in all respects in all phases of the flight." At 20 seconds into the boost phase the guidance system of the *Sergeant* vehicle failed, but the SIGS operated for an additional 11 seconds, the Navy said. The launch was made at the White Sands Missile Range, N.M.
- The Air Force launched two in its series of *Athena* re-entry shots from Green River, Utah, into the White Sands Missile Range, N.M., Aug. 6 and 7. One launch was termed a complete success; the fourth stage of the second vehicle failed.
- NASA launched a series of 13 *Nike-Cajun* rockets from three different sites Aug. 7-9. The coordinated launches from Wallops Island, Va., Point Barrow, Alaska, and Ft. Churchill, Canada, were made to obtain data on noctilucent cloud conditions at high latitudes, to measure the charges that occur following noctilucent cloud formation, and to compare upper-atmosphere measurements made at the three sites at altitudes up to about 100 statue miles.
- NASA's new *Scout Evaluation Vehicle* turned in a perfect performance Aug. 10 in orbiting the Army's *Sequential Collation of Range (SECOR)* satellite from Wallops Island, Va., (see p. 18).
- *Atlas-Centaur 6*, after a week's postponement, was successfully launched Aug. 11 (see p. 16).
- The Navy launched the third in the Air Force's series of four Stellar Acquisition Feasibility Flight (STAFF) tests Aug. 11 from Cape Kennedy. The *Polaris A1*-launched STAFF package failed to lock on the North Star after launch. A secondary missile-induced and natural background illumination phenomena test was successful.

SRAM RFP's Go to 12

Twelve U.S. firms have been asked to submit proposals for development of the Air Force *Short Range Attack Missile (SRAM)*. Proposals are due at the office of the Aeronautical Systems Div. of the Air Force Systems Command, Wright Patterson AFB, Ohio, Aug. 30.

Companies that received RFP's included: The Boeing Co.; Douglas Aircraft Co., Inc.; General Dynamics Corp.; Hughes Aircraft Co.; Lockheed Aircraft Corp.; Ling-Temco-Vought, Inc.; Martin Co.; McDonnell Aircraft Corp.; North American Aviation, Inc.; Northrop Corp.; Raytheon Co.; and Sperry Rand Corp.

Air Force sources estimate production of the missile may total 6,000-10,000 and indicated that a compressed PDP schedule is planned, envisioning the beginning of hardware development early in 1966.

SRAM will be an air-to-surface defense-suppression standoff missile which will probably be used by the B-52, B-58, F-111 and ultimately by the AMSA (Advanced Manned Strategic Aircraft).

SGS Tantalum Process Told

The addition of small quantities of yttrium to tantalum during arc melting increases tantalum's high-temperature strength by some 300% and results in a comparable improvement in the refractory metal's oxygen tolerance.

The improved tantalum has been available for about a year from National Research Corp. under the trade-name SGS (Stabilized Grain Sized) tantalum.

Longer life and improved high-temperature performance have been reported by companies using the modified metal in furnace heat shields, liquid metal tubing, and capacitor leads and caps, say NRC spokesmen.

The oxygen embrittlement problem of tantalum is related to a cancer-like growth process of the grain structure at high temperatures. Small size grains engulf adjacent

Lockheed engineers and scientists have designed a fixed-wing supersonic transport which will cross the Atlantic or Pacific in less than half the time now possible with present subsonic jets.

Lockheed engineers and scientists have designed and developed a rigid rotor compound helicopter which recently flew 272 miles-per-hour.

Lockheed engineers and scientists have designed and developed a hydro-ski assault craft—test bed for a proposed 70 mile-per-hour landing craft that would skim smoothly over the water and rush combat troops to the beaches, 60 miles per hour faster than is possible today.

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grains—constantly extending the grain boundaries. The addition of yttrium in ppm quantities inhibits this growth, resulting in smaller grain sizes much less susceptible to oxygen embrittlement.

Next Titan III-C Detailed

The Air Force's *Titan III-C* launch vehicle will orbit two separate packages in different locations and then go on to demonstrate the rated performance of the versatile Transtage.

Scheduled for launch from Pad 40 at Cape Kennedy in the last week of September, the massive vehicle will be programmed for an initial overspeed orbit of 400/100-mi. shape.

The Transtage will then be burned to circularize this orbit at 400 mi., at which time the MIT-developed radar calibration sphere will be injected into orbit. The Transtage will then shift the vehicle to an elliptical 4,000/400-mi. orbit initiated over Point Arguello. At this point the *OV-2-1* satellite will be injected into orbit.

The Transtage will then go through a sequence of seven 12-second firings, separated by 1-minute intervals to leave the vehicle coasting in a circular orbit approximately 4,000 mi. from Earth. The vehicle will then operate on its attitude control system for some 7 hours as a check on its guidance life.

This second flight test of the *Titan III-C* marks the initial useful payload operation. All subsequent test flights of the vehicle will carry various types and kinds of operational payloads. The third test flight tentatively slated for December, 1965, will involve the first orbital-plane change to achieve a near-synchronous equatorial orbit.

NASA Shifts Personnel

Goddard Space Flight Center is reorganizing its management functions in order to provide better control of its spacecraft programs.

Under Acting Director John F. Clark and Deputy Director John W. Townsend, posts for three additional assistant directors and a chief of advanced plans have been created. Daniel G. Mazur has been named assistant director for technology, handling in-house satellite programs. George F. Peiper, Jr., assistant director for space sciences, will direct sounding rocket projects for the center. Robert E. Bourdeau has been named acting assistant director for projects, which will include *Orbiting Astronomical Observatory, Orbiting Solar Observatory* and *Orbiting Geophysical Observatory.* William G. Stroud has

Lance Fired from Mobile Launcher

PHOTO SEQUENCE shows the Army's new Lance tactical missile in development test firing from White Sands Missile Range, N.M. The program is managed by the Army Missile Command and prime contractor is LTV Aerospace Michigan Div. Hawker-Siddeley is developing the lightweight launcher in Toronto, Canada.

been named chief of the advanced plans staff. Herman E. LaGow will serve as assistant director for systems reliability. Eugene W. Wasielewski continues in his post as associate director for the center.

At the same time, NASA Headquarters has named two new associate administrators in the Office of Manned Space Flight. James C. Elms has rejoined NASA to overlook operations of Kennedy Space Flight Center, Marshall Space Flight Center and Manned Spacecraft Center. Lt. Gen. Frank A. Bogart (USAF Ret.) has been appointed associate administrator for industry affairs.

ATS Studies Go to Four Firms

The Goddard Space Flight Center has named four companies to negotiate contracts for the *Applications Technology Satellite* feasibility experiments and another to negotiate a contract for a *Nimbus* infrared spectrometer.

The *Nimbus* sensor contract, expected to exceed $1 million, will go to the Texas Instruments, Inc.

The *ATS* studies must be completed within 9 weeks and they represent the first phase of work that might lead to additional study or to hardware contracts.

The companies, anticipated contract values, and experiments follow:

Control Data Corp., $45,000 for a type of self-contained navigation system able to determine a satellite's orbit by using only spacecraft observations.

Philco Corp., Western Development Laboratory, $50,000 to study a device capable of determining the attitude of a spin stabilized spacecraft from star measurements.

Bell Aerospace Corp., $47,000 to study an electrostatic accelerometer that could provide information about the relative motion of a gravity gradient stabilized spacecraft.

Electro-Optical Systems Inc., $37,000 to develop a reflectometer experiment to measure degradation of the optical characteristics of materials in space.

Lockheed Spear Motor Fired

Lockheed Propulsion Co. engineers have pronounced the recent test firings of the firm's Spear solid-propellant motor as "highly successful." The firing was viewed as verifying advances in nozzle and propellant technology.

The Spear technology will be applied by Lockheed later this year to continue development testing of 156-in.-dia. solid motors.

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Further AES Experiments Outlined

NASA to start choosing lunar experimenters early next year; nine months allotted for program definition; Earth-orbit work advances

by Hal Taylor

SELECTION OF FIRMS and universities to develop experiments for *Apollo Extension Systems (AES)* lunar orbit and lunar surface missions will be initiated in January, 1966.

A NASA official told MISSILES AND ROCKETS that the schedule would allow the experimenters about nine months to complete program definition of the experiments.

The space agency is already moving toward program definition and hardware funding of a host of experimental payloads for *AES* Earth-orbital missions (M/R, Aug. 5, p. 14). This includes experiments in 15 separate areas and 16 *AES* flights in 14-day and 45-day orbital flights around the Earth.

Together with the lunar orbit and lunar surface tests, the total pricetag for the experimental payloads has now reached $700 million. This does not include the cost of modifying the basic *Apollo* spacecraft or the price of the *Saturn IB* and *Saturn V* launch vehicles to be used in the program.

The Fiscal Year 1966 authorization of $50 million will be used primarily for the program definition phase of the payload integration of *AES* experiments and spacecraft. Hardware funding of some of the Earth-orbital experiments and the program definition phase of the lunar orbit and surface experiments will also begin with part of the money in the current budget.

● **Target dates**—Preparation of plans for the lunar experiments was completed recently by a special NASA scientific community summer study group at Woods Hole, Mass. The group's report was transmitted to NASA, the official said, on Aug. 1 and it is expected to be approved by the space agency by Oct. 1.

After selection of experimenters early next year, submission of program definition plans for the experiments is scheduled for September, 1966. Both the Space Sciences Steering Committee and the Manned Space Flight Experiment Board will review them before hardware development is started.

The official said that prototype development of some of the experiments will be complete by the first quarter of 1967 and prototypes of all of them will be delivered by the end of next year.

Delivery of flight hardware is expected early in 1969.

First Full-Duration Firing of Saturn V's S-IC Stage

S-IC FIRST STAGE of Saturn V lunar mission booster was successfully fired at Marshall Space Flight Center Aug. 5, in first full-duration—150-second—static test. MSFC director Wernher von Braun described it as a "perfect firing." The five Rocketdyne F-1 engines in the stage, for which Boeing is prime contractor, generated the designed total of 7.5 million lbs. of thrust during the record 2½-minute test. After 100 seconds, four of the engines were commanded to perform rapid transverse movements. Officials said this exercise worked as planned.

The official said that while the program definition phase of the lunar surface and lunar orbital experiments has not been completed, the space agency has already identified a long series of tests that it feels are feasible.

● **Moon surface**—Possible lunar surface experiments will be in areas of the geosciences, astronomy and astrophysics. Geological investigations would be primarily surface and resources studies.

Several different plans for geophysical investigations have been proposed, including deep drill study, subsurface probes and seismic measurements, gravity and magnetic field measurements, velocity and propagation of sound, elastic and shock waves in the lunar environment and effects of solar-proton bombardment in ultra-high vacuum.

Also called for in the tentative plans, the official noted, were geochemical investigations. Experiments proposed in this area are mass spectrometry, laboratory investigations of returned samples, X-ray diffractometry studies, X-ray fluorescence analysis, chemical reactions in the absence of gases, neutron analysis, detection of lunar gases and other emanations, vapor pressure determination of compounds in the environment, and studies into the validity of gas laws in chemistry in lunar environment.

Engineering investigations would deal mainly with surface chemistry of particles in ultra-high vacuum (cold welding).

The official said that the astronomical observations probably would be conducted with an optical astronomy experimental package of some variety. Plans call for radio astronomy investi-

gations and photographs to be taken of interstellar media.

The list of possible experiments to be conducted directly on the lunar surface concludes with radiation measurements from outer space, perhaps using a solar wind/X-ray astronomy technique.

● **Moon orbit**—Lunar orbital studies, the official continued, probably will deal with remote sensing of the lunar surface and direct surface measurements.

From an orbiting spacecraft, electromagnetic sensing experiments will be conducted to measure gamma radiation, X-ray fluorescence, ultraviolet fluorescence, absorption spectroscopy, VHF reflection and passive microwaves.

Other potential experimental measurements will be in gravity-gradient and micrometeorite categories.

Direct surface observations will be made with such delivery systems and a lunar hard lander and a lunar soft lander. In addition to the landers, there will be studies with sensors, the official said.

● **Planned compatibility**—In discussing both the Earth-orbital and the lunar orbit and surface experimental programs, the official said that the various experiments would be grouped into compatible payloads prior to the initiation of prototype development.

The grouping of the experiments will include a review to determine areas of study which are of joint interest to two or more of the scientific/technical areas NASA has outlined. This will also include estimates of the size of the experiment as well as its duration, how many times it has to be repeated, and the possible need to know the results of an earlier experiment.

There will also be a detailed study of the common equipment which can be used in the various scientific and technical areas. This is expected to result in the development of laboratories in each area—such as a bioscience laboratory and an astronomy and astrophysics laboratory.

● **Earth orbit**—In addition to plans outlined in last week's MISSILES AND ROCKETS (p. 14), proposed Earth-orbit experiments call for investigations into a broad spectrum of the sciences.

In the area of astronomy and astrophysics the principal fields of interest for potential experiments include surface mapping, morphology, composition and internal mechanisms of astronomical bodies. There would be spectral measurements of radiation originating on Mars and use of a manned solar observatory.

Furthering man's knowledge of the origin and evolution of the universe is a prime interest of astronomers, so attempts would be made to obtain ultraviolet photographs of star fields and emission regions. Interest has also been expressed in possible attempts to map the celestial sphere and photograph the extreme ultraviolet and soft X-ray solar spectrum.

Bioscientific experiments will cover environmentally induced changes in biological material, such as investigation into the effects of weightlessness on living cells or the influence of zero-gravity on human cells. A specific experiment involving salamander limb regeneration under zero-gravity has been proposed.

The physiological responses to weightlessness in animals would be explored through a study of acute and chronic changes of otolith function in frogs during zero-gravity.

Experiments proposed in the area of physical sciences call for measurement of the environment through energy spectrum and intensity of the very heavy nuclei in the primary cosmic radiation, micrometeorite collection and airglow horizon photography.

Fundamental investigations in physics would employ experiments in chemical kinetics free from convective wall effects and further examination of the gravitational deflection of starlight.

Advanced technology and supporting research is another area of possible experimentation, the space agency official continued. Plans call for acquisition of data in such areas as mechanical design, fluid system design and thermodynamic design. There would be a program of testing research models with specific emphasis on the effect of reduced gravity on water electrolysis.

Atmospheric science and technology would be investigated by temperature sounding of the atmosphere from a manned Earth-orbiting satellite.

An experiment suggested for investigating Earth sciences and resources overlaps all areas implied in the field—surface characteristics determination (at microwave frequencies).

Communications and navigation/traffic control promises to be a broad area of investigation. The principal fields of interest for experimentation include determination of characteristics of the propagation medium, optimization of communication relay systems and evaluation of advanced position locating techniques for integration with communications to traffic control facilities. ■

Near-Earth Meteoroid Data Promising

DATA FROM FOUR SATELLITES in near-Earth orbit indicate that meteoroids probably will not be unduly hazardous to manned spacecraft orbiting the Earth for short periods.

NASA scientists made the report at a Symposium on Meteor Orbits and Dust, conducted in Cambridge, Mass., by the Smithsonian Astrophysical Observatory.

It was based on data from two *Pegasus* satellites, the smaller *Explorer XXIII* satellite and the *Explorer XVI* satellite, which ceased operating in 1963.

The third *Pegasus* satellite—launched on July 30—has not been in orbit long enough to yield any useful results. It was launched as the payload on the last of the *Saturn I* research and development flights.

● **Box score**—*Pegasus II* is working normally and reporting useful information on meteoroid punctures of three thicknesses of aluminum skin. It was launched by a *Saturn I* rocket May 25. *Pegasus I*, launched Feb. 16, is reporting on the thinnest panel material (.0015-in.), but mechanical difficulty destroyed the usefulness of data on the .008- and .016-in.-thick material.

By July 20, *Pegasus I* had recorded 104 penetrations in the .0015-in. material while *Pegasus II* registered 61 hits. Calculated for a shorter period of time, the higher frequency reported by *Pegasus II* is believed at least partly due to meteor showers which did not, for unexplained reasons, similarly affect *Pegasus I*.

In the same period *Pegasus II* recorded 30 penetrations in the .016-in. and 14 in the .008-in.-thick aluminum. The difference in total hits is accounted for in part by the amount of surface area of each thickness carried by the satellite.

Explorer XVI, launched Dec. 16, 1962, registered 62 meteoroid penetrations in stainless steel and beryllium-copper detector cells in a 7½-month period. *Explorer XXIII*, launched Nov. 6, 1964, continues to report useful data. Up to July 22, it had recorded 103 penetrations.

The NASA scientists said the satellite measurements have "significantly narrowed the uncertainty" in spacecraft skin thickness requirements, but they called for measurements in thicker materials to round out the knowledge of the flow of meteoroids for long-term flights in space.

Atlas-Centaur Shot Bolsters Surveyor

Highly successful launch after two failures indicates first lunar soft-landing attempt is likely to come before year's end

CHANCES OF SOFT-LANDING a *Surveyor* spacecraft on the Moon before the end of the year were greatly improved by the success of the *Atlas-Centaur 6* flight.

Shortly after *AC-6* placed a 2,100-lb. dummy spacecraft in an almost perfect trajectory on Aug. 11, Vince Johnson, director of launch vehicles in NASA's Office of Space Sciences, said that "*Centaur* is now fully operational."

Officials also announced that the *Centaur 7* stage—which will launch the first engineering and test model of *Surveyor* on a flight to the Moon—has already arrived at Cape Kennedy to begin its checkout.

This is almost certain to mean that the *Atlas-Centaur 7* will be ready for the proposed launch of *Surveyor I* in late November or early December. Although there have been reports that the *Surveyor* spacecraft would not be ready for the launch date, Benjamin Milwitsky, director of the spacecraft project at NASA headquarters, told MISSILES AND ROCKETS that "we will launch the *Surveyor* before the end of the year."

● **No problems**—NASA reported that there were absolutely no anomalies during the *AC-6* flight. The launch vehicle blasted off the pad at Cape Kennedy exactly at the opening of its 10:31 a.m. EST launch window.

Atlas booster performance was nominal and the retro maneuver—which moved the *Centaur* away from the flight path of the dummy *Surveyor* payload—was also performed successfully.

Booster engine cutoff came 142 sec. after liftoff, the insulation panel was jettisoned at 235 sec., sustainer engine cutoff was reported at 415 sec., and a nominal flight was declared at 430 sec.

The *Surveyor* payload aimed at an apogee of 515,000 mi. and a perigee of about 100 mi. with an orbital period of 32 days. Preliminary data indicated *AC-6* came very close to that orbit, with an apogee of 509,829 mi. and a perigee of 105 mi. with a period of 31 days.

The *AC-6* success followed two earlier launch attempts that failed. Originally scheduled for Aug. 4, it had to be delayed when the *Atlas* programmer failed. The second scrub on Aug. 10 occurred when trouble developed in the safety destruct mechanism.

Despite Johnson's declaration that *Centaur* is now operational, NASA officials said that *Centaur 8* and *9*, which will follow the *Centaur 7/Surveyor* shot, are still considered research and development flights. These will also launch engineering models of *Surveyor* on Moon flights, but each has a secondary flight research task.

● **Heat off Atlas-Centaur**—*AC-6* has reduced some of the pressure from Congress, which had called on NASA to study possible use of the Air Force's *Titan III-C* as the launch vehicle for *Surveyor*. If the *AC-7* launch is also successful, NASA probably will decide not to spend the $10 million which Congress approved in the Fiscal Year 1966 budget for the study.

The successful launch will also undoubtedly spur on NASA plans to uprate the *Atlas* booster for later flights of the heavier, 2,500-lb. version of *Surveyor* to be launched in 1967 and 1968.

The uprated *Atlas*—called the *Atlas SLV-3X*—will be given a higher payload capability by lengthening its tankage and making other changes.

Centaur is the only high-energy upper stage currently under development by either NASA or DOD. Plans also call for it to be combined with the *Saturn IB* booster for flights to Mars in 1971 and 1973.

AC-1 on May 8, 1962, failed when the *Centaur* stage exploded before separation from the *Atlas*. The second *Centaur* launch was successful on Nov. 27, 1963. *Centaur 3* on June 30, 1964, accomplished all of its primary flight goals, but a hydraulic pump failure caused a short engine burn. *Centaur 4* on Dec. 11, 1964, also accomplished all of its primary goals, but a planned test of its second burn capability was unsuccessful. *Centaur 5* on March 2, 1965, failed when the *Atlas* exploded two seconds after launch. ■

Pylons Keep Missiles Parallel to F-111

PHOTO SHOWS No. 4 F-111A, first variable-wing F-111 fighter to be equipped with unique under-wing pylons to keep its missiles parallel to its fuselage when wing angle changes. For tests at Edwards AFB, Calif., the General Dynamics/Fort Worth jet aircraft has been fitted with two pylons under each wing, carrying simulated missiles. Wings are at 16-degree angle at takeoff and are swept back to 72.5 degrees for supersonic flight. Rotating pylons compensate for the changes.

McNamara: No Diversion from R&D

But rumors of priority lists continue to disturb Congress; transferals to add Viet-Nam funding could provoke dispute

SECRETARY OF DEFENSE Robert S. McNamara has denied to Congress that any research and development or procurement funds will be reprogrammed to supplement the $1.7 billion already requested, as an amendment to the Fiscal Year 1966 budget, to meet the Vietnamese situation.

However, rumors that the Pentagon is drawing up lists of items that could be trimmed or borrowed from in favor of Viet-Nam are causing concern on Capitol Hill, where there is doubt as to whether Congress can prevent such action.

Members of both houses, led by Sen. John Stennis (D-Miss.), acting chairman of the Senate Defense Appropriations subcommittee, have expressed willingness to vote the Dept. of Defense additional money—even billions—to guard against such Peter-and-Paul borrowing. However, when the question was put formally to the Secretary by Congress, his answer was that no such action would take place. The interchange occurred during a briefing of the House Armed Services and Appropriations Committees on the Viet-Nam situation.

● **Impasse ahead**—Any attempt by DOD to switch funds within its carefully delineated categories—for example, from Air Force R&D to Army Operations and Maintenance—probably would lead to a confrontation between the Secretary and leading members of both houses.

In normal times, the Secretary cannot transfer funds from category to category. As a top staff member on the Hill said, cancellation of one Air Force R&D program would only give DOD that much money to be spent on some other project in Air Force R&D.

There are some loopholes in the appropriations bill which would appear to allow the President to take such actions "whenever he deems such action to be necessary in the interests of national defense." But should the Secretary, after denying intention to reprogram, turned around and take such action, an uproar seems almost certain to ensue.

Nevertheless, both houses agree that the $1.7-billion figure is unrealistic, that more money will be needed even before January, when another supplemental will be requested. The Senate Appropriations Committee is trying to force a more realistic request, in order to forestall any raiding of long-lead-time items.

● **MOL status**—The status of the *Manned Orbiting Laboratory* seems safe as far as a raid on the pot for Viet-Nam is concerned. The language which set aside the $150 million "for no other purpose" in the authorization law and in the House appropriations bill appears to be almost certain to remain in the Senate bill.

Congress has taken a special interest in this program. It has issued many official statements in various committee reports this session urging a go-ahead.

The Senate Appropriations Committee is expected to begin markup of the defense bill this week. The House will not have a chance to go over the $1.7-billion amendment until after the conference is held, making it unlikely that any changes—even additions—will occur as a result of action on the House's part.

● **Other Congressional action**—The Senate Space Committee begins hearings Aug. 23-25 on "National Space Goals for the 1970's and the 1980's" with witnesses from NASA, DOD, Office of Science and Technology, and the National Academy of Sciences.

The Senate Space Committee was considerably irked earlier this year when NASA circulated a document on future goals, which the committee felt gave little information and made no commitments on any programs past the lunar landing. The committee is expected to put heavy pressure on NASA witnesses, including Administrator James E. Webb, to come up with more concrete alternatives.

The House committee meanwhile, having passed the metric conversion study bill, will turn to a resolution on a memorial for Dr. Robert H. Goddard in the next week or so. Although the NASA Legislative Oversight Subcommittee chaired by Rep. Olin Teague (D-Texas) has also indicated a desire to go into future space plans, no dates have been set yet. ■

Solar Observatory Due to Go Aug. 24

NASA plans to launch the third of the *Orbiting Solar Observatory (OSO)* series early next week.

OSO-C will carry nine separate scientific experiments to study the Sun and its influence on the Earth's atmosphere. The launch from Cape Kennedy is scheduled no earlier than Aug. 24.

A better understanding of the Sun's mechanics is expected to help in predicting solar flares whose swiftly generated X-rays could menace manned space flights.

The first two *OSO* satellites were launched from Cape Kennedy March 7, 1962, and Feb. 3, 1965. *OSO I*, which carried 13 experiments, provided more than 2,000 hours of scientific information during its lifetime. *OSO II*, with eight experiments, is still operating.

As were earlier *OSO's*, the new observatory will be launched by a three-stage *Delta* rocket into a planned circular orbit about 350 mi. above the Earth. The orbit will have an inclination of 33 degrees to the equator and a period of about 95 min. If successfully placed into orbit, it will be officially designated *Orbiting Solar Observatory III*. Its useful scientific lifetime is expected to be about six months.

● **Description**—*OSO-C* is physically similar to earlier observatories in the program. It has two main sections—a spinning base portion, called the wheel, which provides gyroscopic stability and carries the telemetry, command system, batteries, control electronics, gas spin-control arms and seven experiments, and a top section, called the sail, which is a fan-shaped device carrying two experiments that point continuously toward the Sun. The sail also has solar cells affixed to convert energy from the Sun into electrical power. ■

SECOR V Upgrading Geodetic Effort

Successfully launched by uprated Scout, vehicle is first built largely by Cubic Corp., and first made spherical for photo tracking job

ARMY's *SECOR V* geodesy satellite has been boosted to the highest orbit achieved by the system in a launch from Wallops Island, Va.

Launched successfully as a bonus payload aboard NASA's uprated *Scout* Evaluation Vehicle (SEV) during its first flight test, Aug. 10, *SECOR V* was reported performing well in an orbit with an apogee of 1,310 n. mi. and a perigee of 611 n. mi. Inclination is 69 degrees and orbital period is 122 minutes.

The preceding four satellites were all orbited at much lower altitudes—*SECOR I,* launched Jan. 11, 1964, with an apogee of 505 n. mi. and a perigee of 490 n. mi.; *SECOR II,* launched March 12, 1965, with an apogee of 562 n. mi. and a perigee of 138 n. mi.; *SECOR III,* launched March 9, 1965—apogee, 508 n. mi., perigee, 480 n. mi.; and *Secor IV,* launched April 3, 1965—apogee, 711 n. mi., perigee, 685 n. mi.

The fifth vehicle was the first built mainly by Cubic Corporation's System Division, San Diego. Earlier satellite vehicles were built by ITT, with Cubic furnishing the transponder and telemetry equipment. Cubic is reported to be negotiating with the Army to provide four more satellites in the program.

The first four *SECOR* vehicles launched are rectilinear, measuring 9 X 11 X 14 in. *SECOR V* is a 20-inch sphere weighing 40 lbs. The highly polished ball was used for this launch because of better reflecting and photographic characteristics. Future vehicles will return to the rectilinear design.

Photographic qualities were desirable in the fifth vehicle to facilitate a photographic tracking experiment. When weather permits, the satellite will be optically tracked by Baker-Nunn camera equipment at the Smithsonian Astrophysical Laboratory, Maui, Hawaii. Effectiveness of these optical measuring techniques can thus be checked against the satellite, which is precisely located by electronic means.

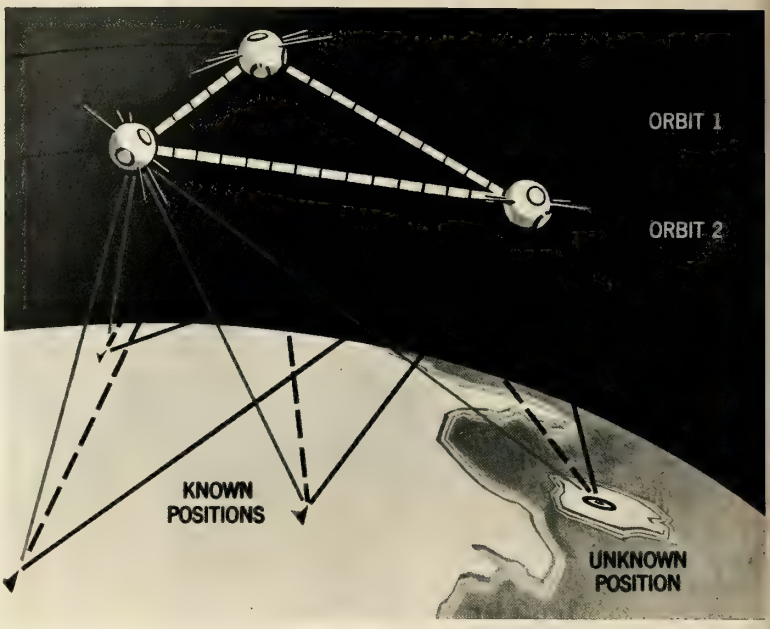
The experiment is designed to test the feasibility of augmenting the satellite's all-weather electronic capability by introducing an optical system. If it is employed, optical gear presumably would be introduced at several ground stations in a deployment similar to that currently used for the electronic equipment.

● **Test to come**—First interrogation of *SECOR V* after a day in orbit was successful and indicated that its components are performing satisfactorily. But actual operation of the satellite as a *SECOR* (sequential collation of range) system will begin only when spin or rotation has stopped. A magnetic stabilization device and other factors are expected to completely halt the spin in 50 days or less.

When first injected into orbit, *SECOR V* was rotating at a rate of 180 rpm. During the first 24 hours in orbit, this rate had dropped to 120 rpm or less and the rate is expected to decrease more gradually until the spin stops.

The improved *Scout's* FW-4 fourth stage imparted the spin to the satellite while successfully placing it in its 69-degree inclination orbit by means of a yaw-torquing or "dog-leg" maneuver. Previous orbit inclination angles from the Wallops Island launch site were about 52 degrees.

The *SECOR* system performs its trilateration operation using the satellite in conjunction with three ground stations at accurately surveyed locations. A fourth station is placed at a ground point whose location is unknown. (Whereas the earlier *SECOR* satellite permitted as much as 2,300-mi. separation between stations, the extra altitude of the fifth satellite's orbit is expected to permit even wider separation of ground points.)



DRAWING SHOWS how SECOR determines exact locations of points on Earth through geometric data obtained after two passes from four ground stations—one "unknown."

Radio signals are flashed from the ground stations to the satellite transponder and returned to the stations during a 6 to 20-minute period when the satellite is within tracking range. During this time, each of the four stations measures the range to the satellite 20 times per second.

● **Extra passes**—Although a single orbital pass would suffice to locate the unknown station, several passes are used in actual operation to afford greater accuracy. The data, recorded on tape, is translated into computer format for use by the Army Map Service.

Each ground station in the *SECOR* system is composed of separate shelters housing radio equipment, data-processing gear, storage and support items. The "fourth" station at the unknown location would change sites with each new effort to obtain an exact fix. ■

AF Wants New Lifting-Body Program

Funding okay sought for PILOT project that would call for two SV-5 vehicles launched from B-52's; Martin, Northrop bidding

THE AIR FORCE is seeking financial approval for a new program involving two manned lifting-body vehicles under the Spacecraft Technology and Advanced Re-entry Tests (START).

The program will cost somewhat less than $10 million and include a series of piloted low-speed tests (PILOT) in a lifting-body configuration tentatively called the SV-5.

This is the second major Air Force effort in the lifting re-entry area. The first is PRIME, Precision Recovery Including Maneuverable Re-entry, already under contract to the Martin Co., Baltimore. PRIME covers the regime from de-orbit to touchdown and involves an unmanned lifting body.

The PRIME vehicle will be launched by an *Atlas SLV-3* booster from Vandenberg AFB late in 1966. The re-entry vehicle will be parachute-recovered in the Kwajalein area and the PRESS network will be used. The vehicle will perform a straight cross-range maneuver in the initial test.

The PRIME program will cost in the neighborhood of $60 million and involve four separate flights. The heat shield for the vehicle is being developed by Martin and will be a silicone-type ablator. The basic structure will be aluminum with some high-temperature metals in certain heat-sensitive areas. The nose cap will be a carbon-phenolic developed by Martin.

A "water-wicking" environmental control system developed by Martin will be included in the vehicles. Control will be by cold gas jets. Honeywell of St. Petersburg, Fla., will handle the guidance system and Northrop-Ventura will develop the modified "stovepipe" parachute recovery system.

● **Rocket-powered**—the PILOT program will have two medium L/D vehicles, each containing a Reaction Motor Div., Thiokol Chemical Corp., XLR-11 rocket engine. Each engine is a four-barrel affair and the firing sequences will be controlled by toggle switches. The powerplant was originally developed for early experimental rocket planes and was used extensively in the *X-15* program before the larger, XLR99 engine became available.

The SV-5 vehicles are not under contract, but both Martin and Northrop are bidding. Both vehicles will be launched from the *X-15* B-52's at Edwards AFB, Calif., in a joint test program coordinated with the NASA lifting-body programs.

The total test project, involving NASA's HL-10 and M-2 vehicles with the two PILOT vehicles, will require a third B-52 in addition to the two already in use at Edwards on the *X-15* program.

Both SV-5 vehicles will be essentially the same. The choice of two vehicles is based on program expediency and a commonsense attitude in running such a research program. Any number of things can happen in a manned test program and a second vehicle procured initially is substantially cheaper than a later buy.

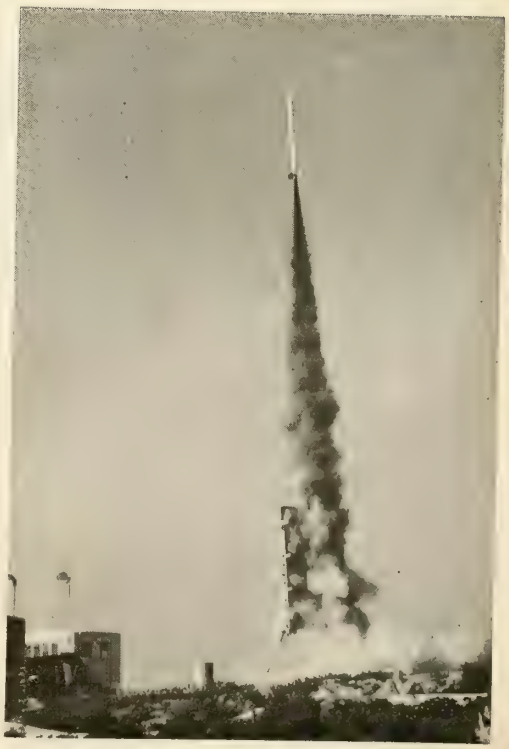
● **Beckoning door**—Air Force officials emphasize that the entire START effort is designed to quickly and efficiently establish the usefulness of lifting-re-entry concepts. If feasibility can be demonstrated, the area is wide open for orbital return approaches.

Lifting re-entry gets operational flexibility into orbital returns and substantially increases the range of landing areas. This has a direct effect in reducing manned and unmanned recovery costs.

In addition to the two major vehicle programs, there are studies into other forms of lifting re-entry methods. These preliminary design efforts cover the cost, weight and mission flexibility of high L/D unmanned vehicles.

Air Force experts do not anticipate problems in the high-temperature re-entry areas with respect to materials or methods of fabrication. There probably will be minor headaches but the technology and materials are said to be well in hand. One Air Force official told MISSILES AND ROCKETS the contractor responses to the SV-5 PILOT program have been remarkably low in their cost estimates. ■

First Photo—French Hybrid Launches



ONE OF THREE French hybrid rockets launched last June by the Office National d'Etudes et de Recherches Aerospatiales at the C.E.R.-E.S. range, Ile du Levant, France. The motors operated exactly as they had in previous ground tests, with thrust variation of 5 to 1, during the 32-sec. firing. The test launches delivered an 11-lb. payload to altitudes of 43 mi., with an all-up launch weight of 170 lbs. The hybrids used a pressurized liquid oxidizer and a rubber-based solid-propellant grain. In the words of the official French announcement, ". . . the supply of oxidizer is obtained by pressurization by means of a gas expanding naturally from a tank, without any regulation equipment."

The only way to grasp the impact of General Electric's role on the Apollo Program is to work here.

The Apollo Support Department is working on the frontiers of reliability, integration and checkout for the NASA Apollo mission. Reliability and quality engineers use mission models to pinpoint critical equipments and sequences in the lunar mission, and simulate entire equipments before they're built to make sure they'll work. Extensions in the reliability art are the order of the day.

The acceptance checkout equipment for the Apollo spacecraft is one of the most advanced ever developed in the United States. It will assure our astronauts' spacecraft is in working order before the mission begins. Other challenging checkout tasks include the electrical support equipment for the Saturn launch vehicle, and special equipment to check out the systems, facilities and personnel in the launch area.

Professional openings immediately available with G.E. on the Apollo Program:

POSITION TITLES	DEGREE REQUIREMENTS	LOCATIONS
Specialists—Systems Management Documentation	BSEE/ME	Huntsville, Ala.
Stage Engineers—Design Review	BSEE	Huntsville, Ala.
Engineers—Checkout Systems	BSEE	Huntsville, Ala.
Engineers—Parts, Materials & Processes or Engineers/Programmers—Systems Reliability Analysis	BSEE/ME/Math	Houston, Texas
Engineers—Test & Checkout; or GSE Requirements	BSEE/ME/Physics	Houston, Texas
Engineers—Systems & Environmental	BSEE/AE/EE/Physics	Houston, Texas
Engineers—Dynamics Analysis	BSME/AE	Cocoa Beach, Fla.
Engineers—Electrical Systems	BSEE	Cocoa Beach, Fla.
PERT Analysts	BSIE/Ind Mgmt/Bus Admin	Cocoa Beach, Fla.
Computer Programmers	BS/Math or Engineering	Daytona Beach, Fla./Houston, Texas Bethpage, L.I., N.Y./Downey, Calif.
Documentation Specialists	College degree required	Daytona Beach, Fla./Cocoa Beach, Fla. Huntsville, Ala.
Engineers—Operational Analysis	BSME/AE/CE/IE/EE	Daytona Beach, Fla./Cocoa Beach, Fla. Huntsville, Ala.

Please write, in full confidence, including salary requirements to: Mr. D. D. Smith, Professional Placement, General Electric Co., Apollo Support Dept., Room 1111-H, Box 2500, Daytona Beach, Fla. 32015.

APOLLO SUPPORT DEPARTMENT
MISSILE & SPACE DIVISION

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Technical Countdown

ELECTRONICS

MHD Generator Pumps Laser

An explosively-driven MHD pulsed-power generator has pumped a neodymium-doped crown glass laser at MHD Research Inc. The generator, developed by the Hercules Powder Co. subsidiary, is capable of producing greater than 10^8 watts of electrical power with an energy output of 10^5 joules. The experimental generator was operated with an initial magnetic field of 2.8 w/m^2. The channel had an electrode separation of 0.15 m and a width of 0.2 m with a length of 1.0 m. Detonation of a 1-lb. charge of C-4 was initiated by a plane wave generator in such a manner as to create a plane front of ionized gas having an initial velocity of 11 km/sec. The generator has an open circuit voltage of 3,200 v, a peak current of 430 KA amps and a pulse length of 200 microseconds. A specially designed coaxial flash lamp filled with argon at 150 mm Hg was used to pump the laser rod. The work is being supported by the Air Force Avionics Lab and monitored by the Aero Propulsion Lab of the Research and Technology Div., Air Force Systems Command.

EOS Develops Laser Hologram

A blue-green hologram using a continuous-wave ionized argon gas laser has been designed and built by physicists at Electro-Optical Systems, Inc. The ionized argon oscillator provides radiation in the blue-green spectrum and thus decreases hologram film exposure times by an order of magnitude. The laser has a power output of 1 watt at a range from 5,145 to 4,545 angstroms. The development permits film exposure times of 10 seconds and brings hologram film acquisition measurably closer to applications in data-retrieval systems and three-dimensional displays.

PROPULSION

LPC Fires Wrung-Out Motor

Lockheed's pulsed solid motor contender for the *SRAM* propulsion system was ignited at a motor temperature of —75°F after nearly a week of temperature cycling and vibration tests. The dual-thrust motor's center-perforated boost grain performed exactly according to specifications, reaching exhaust temperatures exceeding 6,000°F. Some 30 seconds after boost burn-out the end-burning sustainer grain ignited and burned normally until premature termination of the test was caused by a materials deficiency. Lockheed Propulsion Co. officials report the cause was not inherent in the pulse motor system. Prior to the test the motor was cycled between 180°F and —75°F for several days. A low-temperature vibration series was then imposed for 30 hours —over a broad frequency range divided equally between the motor's length and normal to the unit. The Polycarbutene propellant and motor design had previously been test-fired over a 300-degree temperature range. LPC experts consider the design well qualified to meet *SRAM* requirements.

Thiokol To Fire 156-in. Glass Motor

A monolithic glass fiber-wound 156-in.-dia. motor will be loaded and fired in the first quarter of 1966 by Thiokol Chemical Corp.'s Wasatch Div. The 21-ft.-long motor is part of the Air Force 156-in. package series. The other booster units are being built by Lockheed Propulsion Co. Thiokol's motor will have a submerged nozzle and a liquid thrust-vector-control system. Its case is now being wound at the Wasatch Div. under the $3.1955-million fixed-price-incentive-fee contract from the Air Force's Space Systems Div. The upper-stage solid unit will generate some 325,000 lbs. of thrust for 110 seconds. Program is under executive management of the Air Force Space Systems Command, with technical supervision exercised by the Rocket Propulsion Lab at Edwards AFB, Calif.

MATERIALS

Magnetic Fluids Research Let to Avco/RAD

Ferrohydrodynamic fluids will be synthesized and their characteristics studied by Avco Research and Advanced Development Div. under a 19-month contract with NASA's Office of Advanced Research and Technology. Ferrofluids —highly magnetic fluids in forced motion—are not natural but can be produced through a special process perfected at Avco/RAD. The fluid consists of a superfine colloidal suspension of ferromagnetic particles in a liquid carrier. The program will cover fundamental studies only, but the fluids have potential applications in direct-conversion heat engines. In this area, the temperature effects on the magnetic properties of the ferrofluid form the basis for a cyclically-operated unit. A preliminary model has been operated at Avco/RAD. Other applications include guidance and attitude control instruments and pure fluid switches.

SPACE MEDICINE

Russian Rats Adapt to 100% Oxygen

The Soviets report that a 100%-oxygen atmosphere at a pressure of 198-mm Hg did not endanger the life or impair the health of over 12 dozen white rats maintained in that environment for 100 days. The researchers found some distinct changes—such as loss of weight, increased length of pregnancy, and some atelectasis in the lungs of some animals. However, most of the changes reversed themselves after some 50-60 days of the experiment had passed, indicating an effective adaptation.

STANDARDS

NBS Revises Standards Activity List

Miscellaneous Publication 30, *Standardization Activity in the U.S.*, is now being revised by the National Bureau of Standards. The listing currently covers some 350 firms engaged in standardization as a major or important part of their work. NBS is requesting information from all organizations in the U.S. that contribute to the preparation and promulgation of standards. Any organization wishing to be considered for inclusion should send a 200-word-or-less description indicating areas of standardization and accomplishments in the field to Miss Joan Hartman, NBS, Div 405.00, Washington, D.C. 20234.

New Delta May Prove Most Economical

Latest version promises reduced specific cost plus increased payload; could land 220-lb. package on Moon for $16,000/lb.

by William S. Beller

NASA IS SEEKING buyers for rocket launches, and the soon-to-be-fired *Improved Delta,* incorporated into a launch package, may afford today's biggest bargain.

One potential customer is the European Space Research Organization (ESRO). It is considering buying the vehicle launches to carry some of Europe's scientific satellites into orbit. Arnold Frutkin, director of NASA's Office of International Affairs, says he's "optimistic" a deal will go through.

The space agency's ability to work out a cost figure for *Delta* launches free from the haze of accountants' indeterminables is considered an achievement equal to the improvement of the launch vehicle itself (M/R, June 7, p. 21).

The increasingly favorable performance and economy of a *Delta* launch is remarkable: the original *Delta* vehicle, used from 1960-62, exhibited a specific cost of about $5,000/lb. to put a 525-lb. satellite into a 300-n mi. orbit; the *Improved Delta* shows a specific cost of only half as much, and a payload more than doubled, to 1,400 pounds.

By the late 1960's, the comparable cost of a *Delta* launch is expected to approach $1,000/lb., and an increased payload capacity, according to the estimate of William R. Schindler, *Delta* project manager at Goddard Space Flight Center. Larger launch vehicles such as the *Atlas-Centaur* or *Titan III-C* would undoubtedly have lower specific costs, but the problem of getting sufficient payload for the vehicles arises.

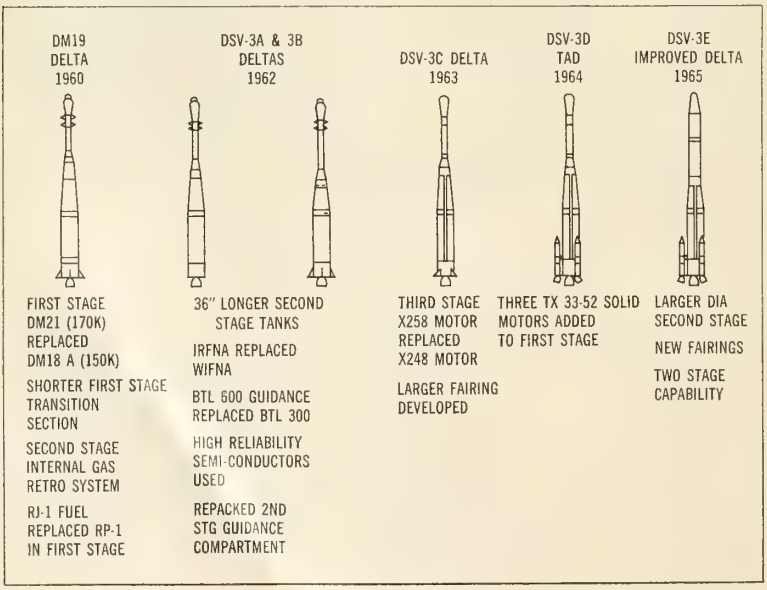
It is difficult to get cost figures for launch vehicles other than *Delta* because NASA has not had to break them down as it did for such projects as American Telephone and Telegraph's *Telstar I* or Comsat Corp.'s *Early Bird.* The *Telstar I* launch cost about $2.9 million; *Early Bird,* which used a more powerful *Delta,* $3.3 million. These satellites have higher than the quoted specific costs because of differences in the spacecraft orbits and weights.

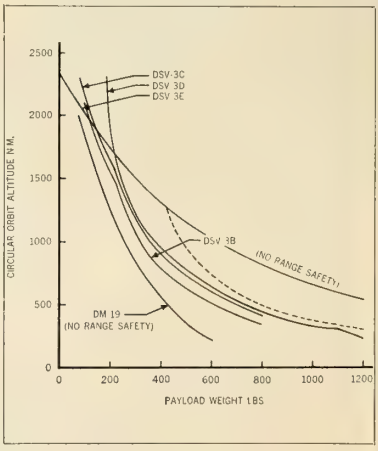
● **Cheap Passage to the Moon**—The *Improved Delta* could be used to hard-land a 220-lb. package on the Moon, or send a 165-lb. spacecraft on a Mars fly-by. These are missions only recently recognized to be within *Delta's* capability but not yet officially considered.

The cost of launching the *Delta,* either to a low Earth orbit or into interplanetary space, would be the same. Thus, the specific cost to send a package to the Moon by the *Improved Delta* would be $16,000/lb.; and on a Mars fly-by, about $21,000/lb.

Even with these seemingly nominal costs, European countries would find it cheaper to work with NASA on joint programs and have the space agency furnish launchings and facilities while European scientists furnish some of the scientific experiments or even the satellities. The drawback to this arrangement is that it limits European scientists to experiments the U.S. space agency considers as not duplicative of U.S. work and of sufficient scientific merit.

The world will probably not know what the Moon's surface consists of or its physical state until an operational soft-lander gets there. Yet the *Improved Delta* with its lunar payload package is





ABOVE: Delta circular orbit capabilities from Atlantic Missile Range, inclination equals 33 degrees.

LEFT: History of Delta Improvement.

SHARP-CHUTER

America's Minuteman missile is best known for intercontinental marksmanship. But its technology also contributes "bull's-eye" accuracy for tomorrow's all-weather parachute drops—at high or low altitudes.

NAA/Autonetics designed and built the guidance systems for Minuteman I and II, and is now applying its Minuteman II microelectronics experience to fully-integrated strike avionics systems.

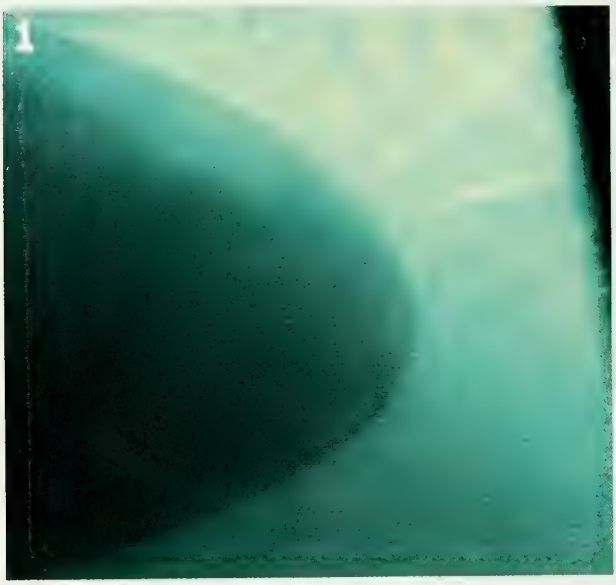
In an airborne troop carrier, these systems can pinpoint the "drop zone" day or night, in any weather.

Minuteman reliability by NAA/Autonetics is also setting the standards for the industry in other complete avionics systems. In inertial navigation, computer, and radar systems. Command and control systems. Reconnaissance, surveillance, and weapons systems.

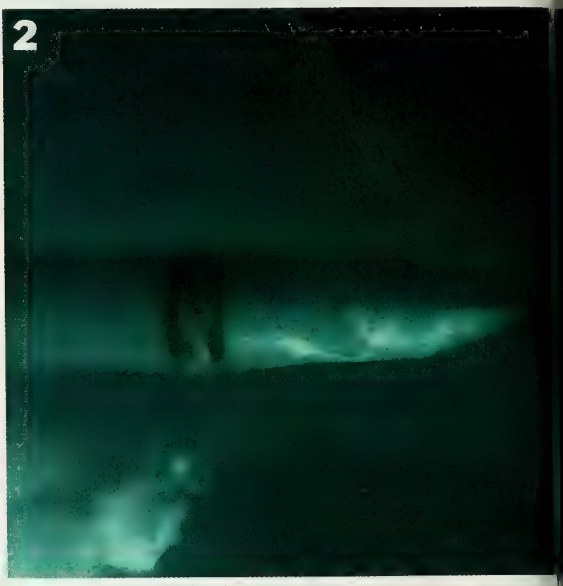
For more information about Autonetics total systems capability in meeting the electronics needs of the future, please write: Director of Marketing, North American Aviation/Autonetics Division, 3370 Miraloma Avenue, Anaheim, California.

North American Aviation Autonetics Division

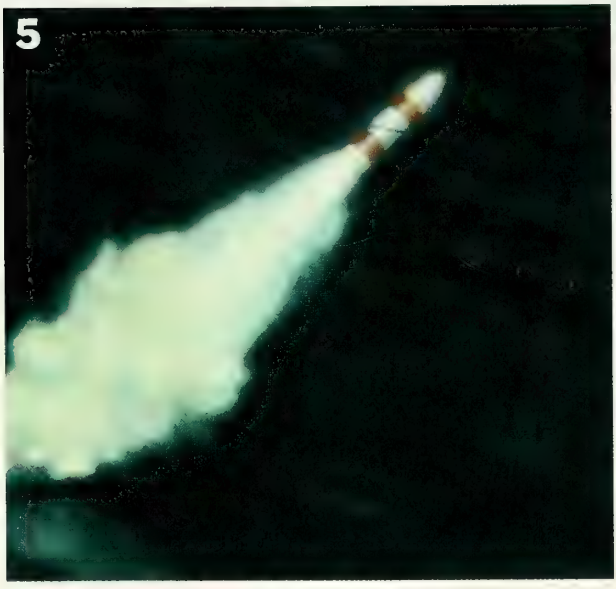
SUBROC combines the surprise of a t



Bow of a nuclear attack submarine.



SUBROC fired from torpedo tube.



Accelerating to maximum speed under airborne guidance.

SUBROC continues on prescribed trajectory.

SUBROC...success story

When national defense requirements call for a new weapon system for a new role or a new environment, one of Goodyear Aerospace management teams is ready to go along with it —and all the way. Unique problems require imaginative engineering solutions—the kind we cultivate at Goodyear Aerospace.

Take SUBROC, the Navy's newest submarine-launched guided missile.

SUBROC is the first tactical weapon system capable of underwater launch and ignition . . . airborne trajectory . . . underwater detonation. It unites the best tactical characteristics of the torpedo, the guided missile and the nuclear depth cha SUBROC combines surprise, speed, range, accuracy reliability.

SUBROC's development called for big advances in the s of the art. It called for strong management capabilities.

GAC—as prime contractor to the Bureau of Naval Weap with Naval Ordnance Laboratory as technical directo managed the industrial team on the SUBROC program f early development to operational status. GAC is now ducing the missile as well as much of the ancillary equipm

The specifications were rigid and without precedent.

› with the speed and range of a missile.

ater ignition and programmed upward turn.

SUBROC emerging from water to airborne flight.

eparation of warhead from booster.

Nuclear warhead on course to enemy submarine.

eapon system management

ry system was to be a nuclear attack submarine and apon to be launched from the torpedo tube. Detection, ng, fire control and the configuration of the missile . . were tailored to these tight parameters. The pro- s success is a triumph over obstacles on which an t had never before been made.

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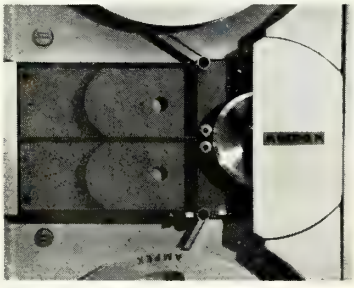
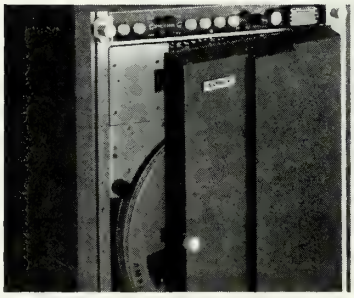


FR-1600 Lab-Type Recorder

Unique vacuum drive system insures stable tape motion; reduces ITDE, TBE; minimizes flutter to less than 0.2%. Reels up to *16 inch* for 33% more playing time. Up to 14 channels of record and reproduce in one cabinet.



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theoretically able to hard-land about 150 lbs. of instrumentation plus a kick motor or soft-land a lesser weight.

Experimenters from time to time have suggested devising lightweight payloads to test out the lunar surface, either by the spectroscopic analysis of a flare burst on the Moon or by data telemetered back from a single-purpose instrument package. Douglas Aircraft Co., Electro-Optical Systems, Inc., and Sperry Gyroscope Co. are among those who have studied such schemes, but with scant space agency encouragement.

Only the most drastic change in the current notion of what the lunar surface is like could now influence the LEM design. However, plans for exploiting the lunar surface through bases, mobile units, power installations and such are now going on. Barring a successful Soviet soft-lander and a subsequent sharing of data, the U.S. will not know the character of the lunar surface until late 1966 or early 1967, which are the optimistic dates for the operational *Surveyors* to land on the Moon. Late this year or early next, *Surveyor* engineering spacecraft are to be launched, but they are not to analyze the lunar surface beyond taking pictures of it.

If the *Advanced Delta* were used, it possibly could furnish some of the needed lunar data many months in advance of *Surveyor* and at a fraction of the cost.

This fall the *Improved Delta* is to launch *Geos,* a 350-lb. NASA Headquarters geodetic orbiting laboratory. This will be the first use of this version of the *Delta,* whose assembly and check-out started at Cape Kennedy this week. Of high credit to the designers of the *Delta* launch vehicle is that their development shots have all been operational ones.

● **Impressive schedule**—The merit and high reliability of the *Delta* is reflected in the mission schedule for the improved vehicle. After *Geos,* a *Pioneer* series of satellites will be put into heliocentric orbits as part of an Ames program. In the first quarter of next year, the first of six operational *Tiros* satellites, known as *TOS,* is scheduled for an *Improved Delta* launch. *TOS* will weigh about 300 lbs., will be doglegged out of Cape Kennedy into a 750-n. mi. polar orbit.

By next summer, Goddard hopes to use the vehicle to launch its anchored *IMP* satellite into a lunar orbit to gather data about energetic particles in cislunar space. (This project was once called *Lunar IMP,* but the acronym was too hazardous.) This *IMP* satellite will weigh 212 lbs., 80 lbs. of which will be a kick motor to turn the satellite into lunar orbit. The *Improved Delta* is also scheduled to launch the 1,200-lb. *Bios* satellite into a low Earth orbit of about 200 n. mi. next summer. Only two of the *Delta's* three stages will be used for this firing.

Douglas Aircraft Co. is systems manager for the *Delta* vehicles, under the direction of Goddard Space Flight Center. With 30 successful launches out of 32 tried, the *Delta* series is among the most reliable multistage rockets ever launched. Schindler freely admits that its continued development has been through "stealing and adapting" ideas wherever possible. Through this engineering technique, *Delta's* payload-carrying ability has about doubled from the first vehicle to the one now at Cape Kennedy.

Schindler is looking forward to using fluorine and hydrogen or fluorine and hydrazine as *Delta* propellants. "The country is ripe for a breakthrough such as this," he said, "and there is a limit to what strictly engineering improvement can do."

In the meantime, the *Delta* project manager sees a way to upgrade the *Improved Delta* through the Air Force's current *Thor* program at the Space System's Div. The military service is stretching the *Thor* tankage so it can hold more propellant, and is improving the strap-on *Sergeants* used in harnesses of three on the Thrust-Augmented *Delta* (TAD); this vehicle was used to put *Early Bird* into orbit last April. Possibly bigger solids such as Aerojet Sr.'s could be strapped on.

Schindler believes that this Air Force work could lead to bettering the *Improved Delta* performance by 20%.

● **Vanguard contributions**—It is ironic that the fabulously successful series of *Delta* rockets is based on much of the hardware and concepts used in the presumed failure called *Vanguard.* In 1959, the Air Force took the upper two *Vanguard* stages, mounted them on *Thor,* and called the combination *Thor-Able.* NASA then made minor modifications in the vehicle's coast attitude-control system and put in a new autopilot control system; but the basic *Thor-Able* shell was used. This was the *Delta* that failed in its first firing in 1960 with an *Echo* satellite payload. The subsequent *Deltas* orbited their payloads in 22 successive launchings.

The *Vanguard* program, too, besides giving birth to *Delta* was probably one of the most economical buys of the U.S. space program. Originally budgeted for a total cost of $20 million, *Vanguard* ended up costing $105 million, which paid not only for development of the *Vanguard* hardware and several launchings but also for setting up the world-wide Minitrack network used in project *Mercury.*

Improvements in *Delta* from 1960 to the present involved using more energetic propellants, lengthening the second-stage tanks, replacing the third-stage motor for a more active one, adding solid strap-ons to the first stage, and again enlarging the second stage.

The result is an inexpensive and reliable bus whose launch can be bought for less than $3.5 million. ■

Specifications for Improved Delta Launch Vehicle

Over-all Characteristics

Height: 92 ft. (including shroud)
Maximum diameter: 8 ft. (without attached solids)
Lift-off weight: About 75 tons
Lift-off thrust: 333,550 lbs. (including strap-on solids)

First Stage

(A modified Air Force Thor, produced by Douglas Aircraft Co., engines produced by Rocketdyne Div. of North American Aviation.)
Diameter: 8 ft.
Height: 51 ft.
Propellants: RP-1 kerosene and LOX
Thrust: 172,000 lbs.
Burning time: About 2 minutes, 27 seconds
Weight: Approximately 67 tons

Strap-on Solids

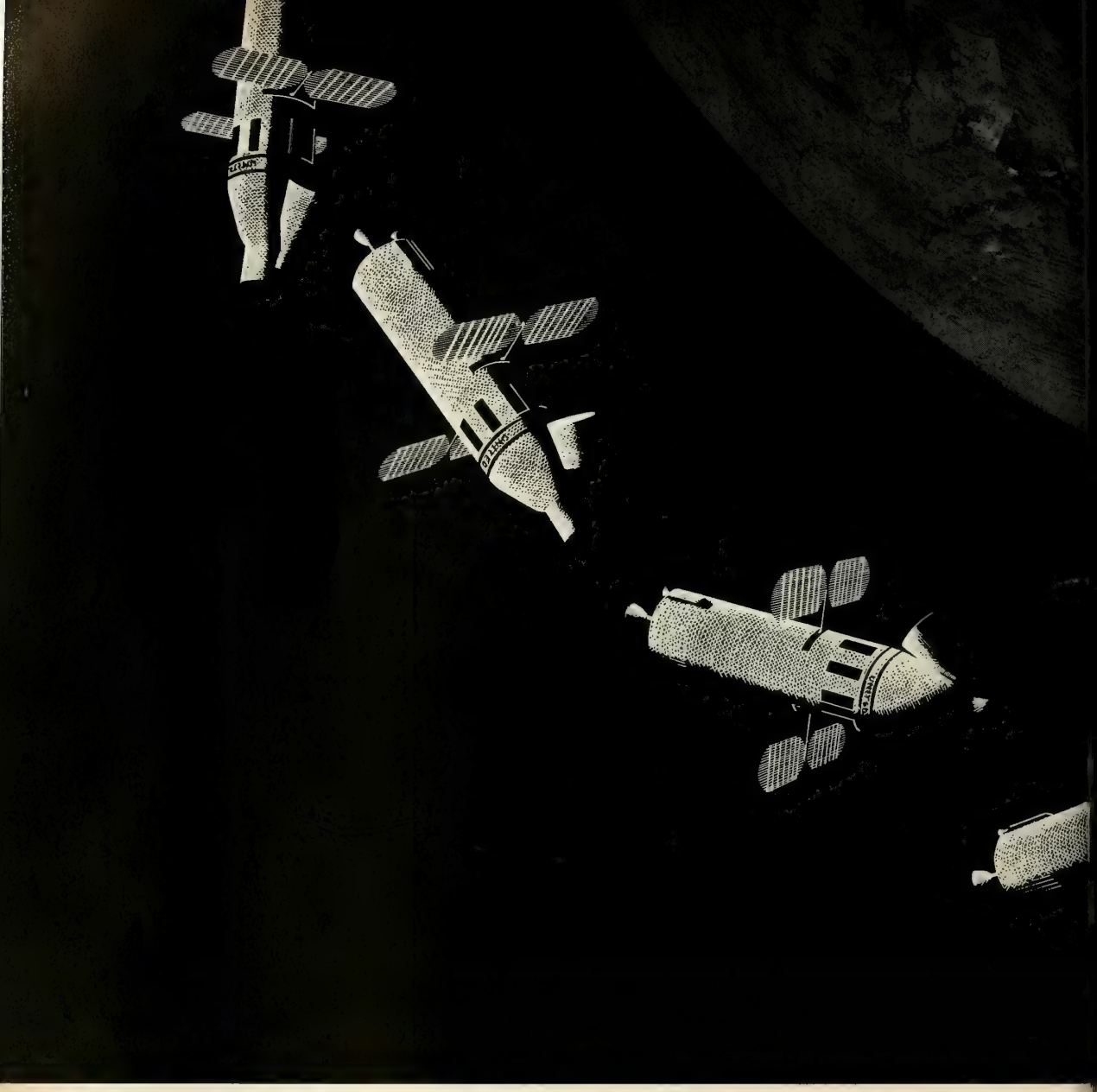
(Three solid-propellant rockets produced by Thiokol Chemical Co.)
Diameter: 31 in.
Height: 19.8 ft.
Weight: 9,170 lbs. each
Thrust: 53,850 lbs. each
Burning time: 33 seconds

Second Stage

(Produced by Douglas Aircraft Co., using an Aerojet-General Corp. propulsion system; major contractor for the autopilot include Honeywell, Inc., Texas Instruments, Inc., and Electrosolids Corp.; guidance contractor is Western Electric Co.)
Propellants: UDMH and red fuming nitric acid
Diameter: 4.7 ft. (compared to 2.7 ft. for earlier Delta)
Height: 16 ft.
Weight: 6½ tons (compared to 2½ tons for earlier Delta)
Thrust: About 7,800 lbs.
Burning time: 400 sec. (compared to 150 sec. for earlier Delta)

Third Stage

(Allegany Ballistics Laboratory, X-288 motor.)
Propellants: Solid
Height: 3 ft.
Diameter: 1½ ft.
Weight: 570 lbs.
Thrust: 5,750 lbs.
Burning time: 28 seconds



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Public Ignorant of A-ICBM Situation

Newly released survey conducted for Pentagon planners shows ⅔ of U.S. adults believe defense system exists

by Donald L. Zylstra

THE AMERICAN PUBLIC apparently knows appallingly little about the nation's missile defense. This is true in spite of the acknowledgement that public opinion may influence eventual deployment of *Nike-X*.

A survey completed in the early fall of 1964 by General Electric Company's TEMPO group, Santa Barbara, Calif., for the Advanced Research Projects Agency (ARPA) and the Office of Civil Defense (OCD) has outlined public reaction for the Dept. of Defense. Data developed by the survey was withheld by the Pentagon until its release this week.

The salient single finding in the 126-page TEMPO report was that, despite the fact that no anti-ICBM system has been authorized or deployed, about two-thirds of adult U.S. citizens apparently believe the nation is now protected by an A-ICBM system (M/R, Aug. 2, p. 15). The survey is titled "Public Opinion and Ballistic Missile Defense—Report of an Exploratory Survey," and dated Sept. 30, 1964 (M/R, Aug. 9, p. 46).

Considerations that brought about the survey, resulting in a representative sampling of adults in 72 localities, were outlined in the report:

"Any non-deployment decision, whether 'temporary' . . . or 'permanent' . . . will probably prompt opposition statements from responsible and informed people. To the extent that such policy debates are brought to the public attention they may stimulate healthy thought and debate, may generate confusion, and of course, may conceivably produce widespread opposition to the announced policy.

"Deployment decisions likewise may trigger public reaction focused directly on the ballistic missile defense itself, or on some other related program or policy. Foreknowledge of the likelihood and nature of such reactions would be very helpful, if not indispensable, to the ballistic missile defense (BMD) policy maker. It would probably have a pronounced influence on the methods of policy announcement and program implementation; it may even influence the policy itself."

The actual TEMPO survey was conducted by the National Opinion Research Center (NORC) of the University of Chicago. Interviewing was intended to produce valid returns from 1,500 adult citizens. Pressure of time, however, resulted in portions of the survey questions being asked of a group of 1,248 adults. Others items in the questionnaires used were posed to a total of 1,399 interviewees.

• **Considerable confusion**—TEMPO survey evaluators came to the conclusion that "real knowledge about anti-ballistic missiles is very low" in the U.S. In addition to the widespread belief that the nation is protected by a non-existent anti-ballistic missile defense, 59% of persons interviewed also believe the Soviets now have such a system deployed.

Respondents who correctly identified an anti-missile missile as the means by which their government would conduct a ballistic missile defense totaled 42%. Only 66, or 4.7% of the total, could mention a nuclear warhead when asked "how these anti-missile missiles would work."

In rating comparative effectiveness of U.S. defenses, the group sampled gave highest marks to the ability to defend against hostile aircraft. Effectiveness of defenses against both enemy missiles and submarines scored virtually equally. The survey group rated the defense against enemy bombers as 82% effective; against hostile missiles, 71%; and against submarines, 72%.

In assessing the actual conditions of the nation's defenses, the report noted that "even knowledgeable defense authorities would probably not agree on the 'degree of perfection' of current U.S. defenses. It seems probable that such experts would rank the three classes of defense in the same relative order as did the public, but that a somewhat wider gap would exist between anti-missile defenses and the other two."

• **Helpless feeling**—Apparently the average citizen is convinced that, whatever measures are taken for his protection against missiles, he will be permitted no say, no participation in such decisions. The report notes that, while "about 80% of the sample (group) feels that deployment of something that can shoot down missiles attacking our cities is a good idea," about 70% of the population "feel that they could do nothing about a decision to deploy BMD at their city, or about a decision not to include their city in a deployment."

About half of the survey respondents say they would feel they ought to do something to get BMD if their city were omitted from a deployment. In commenting about the "apparent contradiction" between citizens feeling that they "could do nothing" and that they "ought to do something," the report notes that "it cannot be explained at present."

A total of 86.7% of persons interviewed considered placing anti-missile missiles around all larger cities in the U.S. desirable. Those who would prefer to live in such protected cities totaled 70%. No indication of the cost of such BMD protection was offered interviewees in the survey questionnaire.

• **Threat to TV**—When interviewers suggested the hazards that might accompany deployment of a BMD system in their community, "a strong majority continues to favor the idea of BMD, but there is a definite drop in overall desirability scores," the survey report said. The hazard occasioning the greatest drop in BMD desirability was the possibility of accidental anti-missile firing.

When the possibility that BMD might destroy "just about all enemy mis-

siles attacking a city—maybe 9 out of 10" was suggested, favorability scores increased. "An intercept ratio of 1 in 3 decreases favorability," the report said.

Other hazards the questionnaire suggested in connection with BMD deployment included: "if the real estate values went down a little; if the radar . . . may cause poorer television reception around here; if it means that we must set up shelters for everyone; if there might be some local opposition; if they take up a lot of acres that could be used differently."

A section of the report discussing peacetime hazards to civilian population also observes: "The main phased-array radar (in a BMD system such as *Nike-X*) will operate with concentrated beams at high power levels. This may require rearrangement of air traffic patterns; it may cause interference with radio or TV reception. It has even been suggested that a rain of dead birds may serve as a constant reminder of anti-ballistic missiles' vigilance."

● **First in war**—In ranking six suggested classes of U.S. cities which should be given top priority in anti-ballistic missile deployment, the sample group placed them as follows: cities with military installations; cities with most industry; cities with largest population; cities with transportation; cities drawn by lot; cities of historical importance.

"When given a list of 21 pre-selected large U.S. cities to rank in BMD-priority order, people rank Washington and New York far ahead of any others," the survey said. "Next come San Francisco, Chicago (and) Los Angeles."

Half of the people sampled believe the current cold war may continue indefinitely, although 84% found this undesirable. Eighty percent feel that World War III would be an undesirable way to end the cold war—but "31% think it likely that one will occur."

Asked to consider how any global war is likely to occur, the greatest number of interviewees (27%) considered escalation from non-nuclear war most likely. Another 24% viewed a controlled exchange as most likely and 23% considered war breaking out as an "all-out spasm" most probable.

More than 90% of persons sampled expect some type of nuclear exchange in the event of a world war. "This probably demonstrates little more than that the term 'world war' has become accepted by most people as a synonym for nuclear exchange," the report said.

In ranking priority that the Soviets would probably assign to U.S. targets, people interviewed placed them in the following order: military bases; factories and transportation centers; cities; people. (The survey report noted that a possible defect in the prepared field questionnaires was the omission of a "governmental centers" choice, in relation both to Soviet targeting and to ranking of American cities which should be protected.)

The report observes that the U.S. has expressed "a willingness to forego, under certain conditions the deployment of ballistic missile defense systems . . .

"While the United States may not be irrevocably committed to a policy of non-deployment of ballistic missile defense," the report observes, "it has given strong evidence that it would prefer such a policy and looks with favor on the establishment of conditions under which such a policy could be adopted."

● **Neither public nor classified**—Notes on the inside cover and on the title page of the TEMPO survey appear somewhat contradictory. The cover note reads: "Not for public release—This document not approved for open publication, nor for distribution to the Office of Technical Services, Department of Commerce. Qualified requestors may obtain copies from the Defense Documentation Center."

The title page observes: "This report has been reviewed by the Department of Defense and approved for unclassified publication." ■

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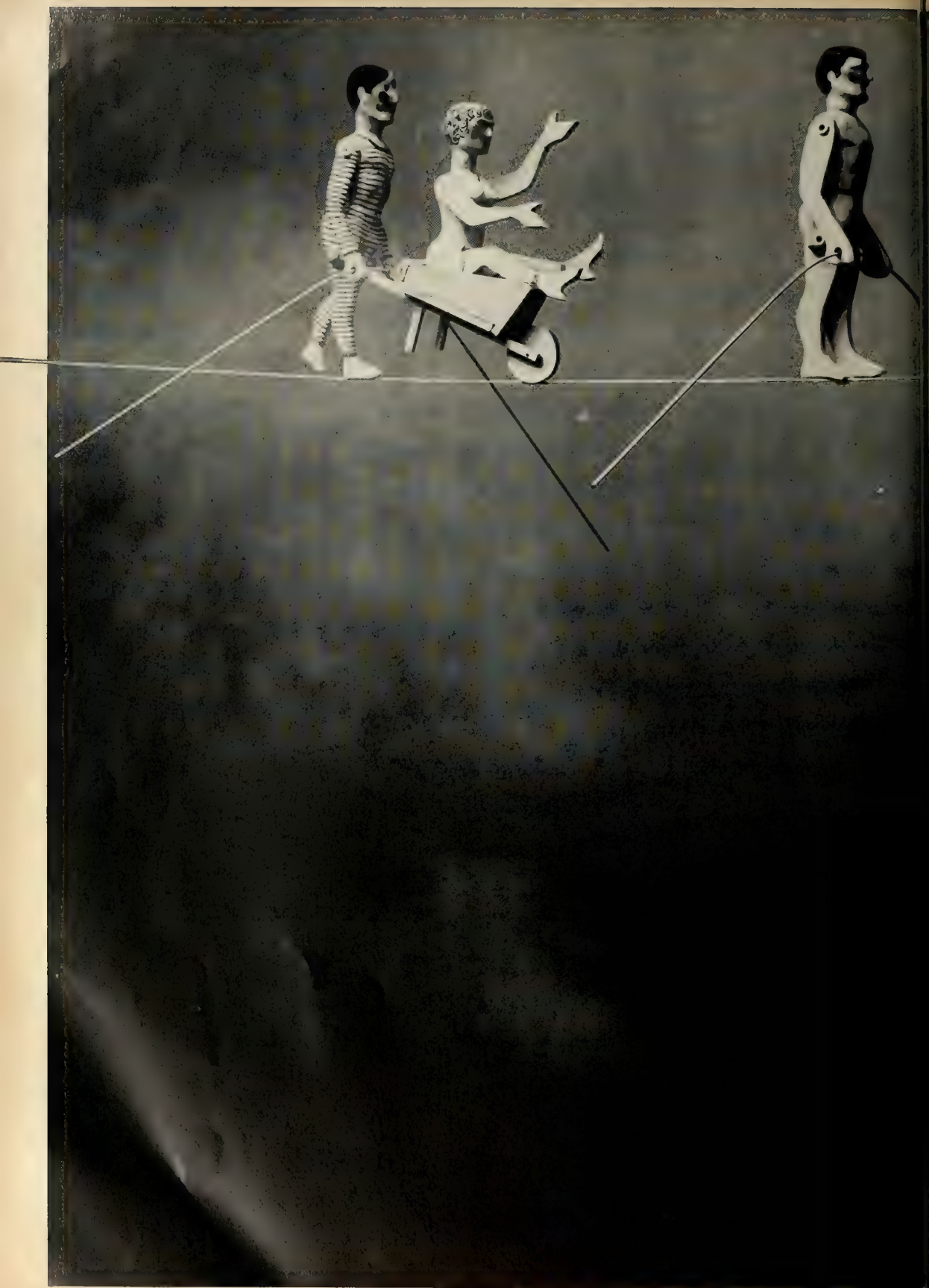

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Random Drift (deg/hr)						
Vertical (short term)	0.05	0.05	0.03	0.05	0.05	0.02
Azimuth (short term)	0.10	0.10	0.10	0.05	0.05	0.03
Gimbal Freedom (deg)	±10 IA	±16 IA	±2.5 OA	±3.60 OA	±3.6 OA	±3.0 OA
G-Sensitive Shift (deg/hr/g)	0.5	0.5	0.5	0.15	0.5	0.7
Anisoelastic (deg/nr/g^2) Peak	0.02	0.02	0.02	0.02-0.05	0.02-0.05	0.02
Operating Temp. (°F)	180	170	160	165	165	115
KING SERIES	**C70 2519**	**C70 2519**	**C70 2519**	**C70 2519**	**C70 2538**	
Typical Dimensions: 2″ diam. x 3″ long	001	005	008	010	000	
Angular Momentum (gm cm^2/sec)	5.1×10^5	5.1×10^5	5.1×10^5	5.1×10^5	3.5×10^3	
Random Drift (deg/hr)						
Vertical (short term)	0.003	0.03	0.003	0.005	1.0	
Azimuth (short term)	0.015	0.03	0.015	0.05	1.0	
Gimbal Freedom (deg)	±2	±2	±2	±2	±3	
G-Sensitive Shift (deg/hr/g)	0.2	0.2	0.05	—	2.0	
Anisoelastic (deg/hr/g^2) Peak	0.01	0.01	0.01	0.005	0.02	
Operating Temp. (°F)	150	115	150	143	200	

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Ames Exobiologists Provide Major Link In Understanding Origin of Life on Earth

A MAJOR ADVANCE toward explaining the origin of life on Earth has been accomplished by scientists at NASA's Ames Research Center.

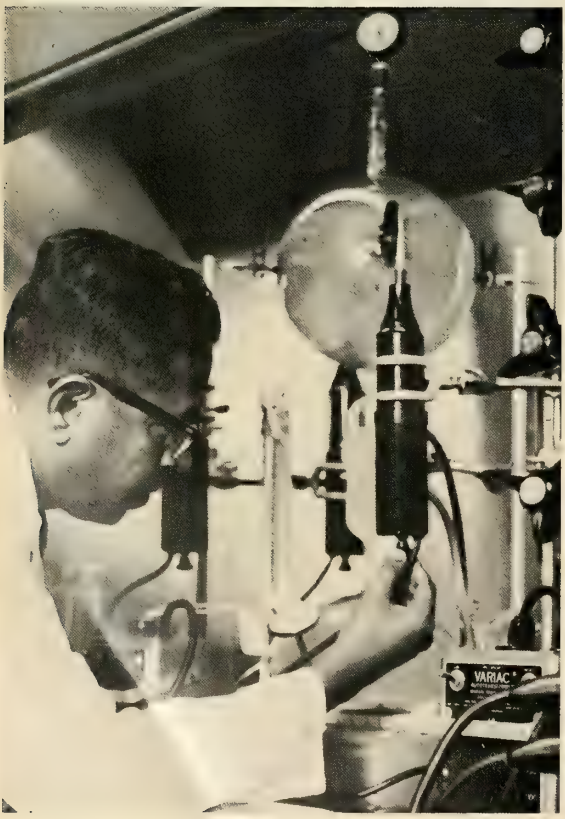
Dr. Cyril Ponnamperuma of Ames Exobiology Division led a research team that has synthesized, in good yield, the five chemical building blocks of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) in a simple laboratory model under conditions believed to duplicate those existing on Earth in primeval times. (Previously, NASA says, synthesis has been accomplished but only through lengthy, complex procedures.)

The principal constituents of the Earth's atmosphere at that time were water, methane and ammonia. From 3 to 4½ billion years ago, it is estimated, these constituents received a constant heavy bombardment of ultraviolet rays from the Sun. They also were exposed to particulate radiation, lightning, and extremely high temperatures from the volcanic activity of the Earth's crust.

As explained by NASA scientists, complex organic molecules began to evolve later as other conditions affected the "primordial soup," including exposure to highly reactive chemicals, other energy sources and constant wetting and drying on the shores of water masses. With the nucleotides as a base, organized molecular complexes, behaving as living cells, eventually were formed.

It was this step—the synthesis of the nucleotides that are composed of a nitrogeneous base, sugar and a phosphate in a simple process—that NASA scientists believe provides the secret to the chemi-

LEFT: Dr. Ponnamperuma studies simulated "primordial soup," conditions believed to have existed on Earth billions of years ago. RIGHT: Other studies at Ames involve simulation of the environment of Mars, including seasonal and day-night cycles, to determine whether Earth-type microorganisms could have evolved and grown in those conditions.



cal evolution of organic material which had to occur before life could appear.

● **Experiments**—Dr. Ponnamperuma has been closely identified with the scientific quest for knowledge of the origin of life. In research done at Ames earlier, he, assisted by other NASA scientists, was able to retrace part of the process by causing some of the bases and sugars needed to form nucleic acids to form by adding energy to the basic methane, ammonia and water of the simulated atmosphere. These included the bases adenine and guanine, and the sugars ribose and deoxyribose.

With additional work, they were able to induce these bases and sugars to combine, lacking only the addition of phosphate to make a DNA building block, a nucleotide. By adding a variety of inorganic phosphates, and adding heat (180°F) at a fairly low temperature, they were able to synthesize nucleotides.

Of these five nucleotides, only four each appear in the nucleic acids DNA and RNA, thereby causing the difference. DNA has all but the nucleotide that contains the nitrogeneous base uracil; RNA lacks the one with the base thyamine. It is the arrangement of these —in an almost infinite number of combinations and sequences—that is the blueprint for the organism of which the cell is a part.

The DNA chain of simplest, primitive organism contains perhaps a hundred thousand of these nucleotides; a human cell DNA chain may have billions. They form in a double spiral chain in the DNA molecule in common combinations that appear to carry the specifications of the entire organisms.

The RNA chain, almost identical except that it consists of only a single spiral and differs in the nucleotides, forms on the DNA chain. It attracts other organic molecules to duplicate its own pattern, serving as a template for creating new living cell material. Eventually it gives rise to new cells from organic material in existing cells.

● **Next step**—Dr. Ponnamperuma, who has been assisted in his current work by Ames scientist Ruth Mack, will now turn to the possibility of joining the nucleotides, to see whether a DNA chain can be evolved.

According to NASA, the scientist has found some preliminary evidence of the joining of perhaps two or three nucleotides in such a manner. His plan now is to seek possible catalysts that were present in the primitive Earth "soup," to generate long molecular chains under primitive Earth conditions.

NASA hopes that by reaching an understanding of how life originated on Earth and under what conditions, it will shed light on whether life could have evolved, or may still evolve, elsewhere in the solar system. ■

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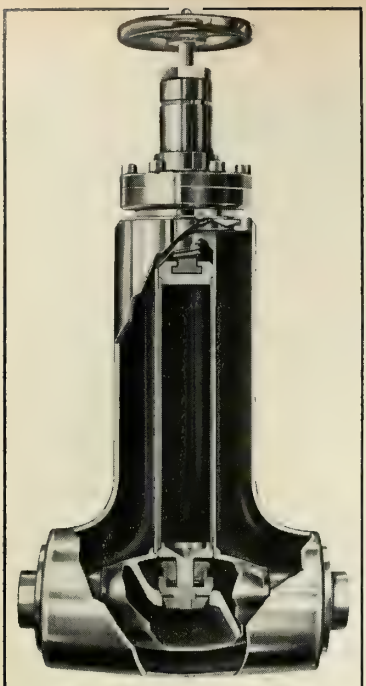


It solved our cryogenic fluid handling problem... We think it will solve yours, too.

Question: What do you do when you can't find a commercially available valve to meet your exacting requirements for cryogenic transfer line systems? Answer: Design your own. This is just what our engineers did, the result: a new series of jacketed and unjacketed valves for low loss handling of cryogenic fluids in five sizes from ½" to 2". Here are just a few of their features that we think will help solve your problems: high flow . . . low cool-down losses . . . low heat leak . . . bubble-tight shut-off . . . zero stem leakage . . . ease of operation and, most important, reliability. What's more the Series V-1060 Valves are available in three modes of operation—Manual, Cylinder and Positioner. Why not get the facts, write for our Bulletin 206.

cvi®
CryoVac INCORPORATED
COLUMBUS 12, OHIO

Aerojet Tests Toroidal Motor

A TOROIDAL MOTOR using a pintle nozzle is the latest solid propulsion contender for space missions at Aerojet-General Corp.'s Sacramento, Calif., plant.

The 15-in.-dia. doughnut-shaped motor was thrust-modulated several times over its 10-second test firing. Dr. Werner R. Kirchner, vice president and assistant general manager at Sacramento says the simple addition of an already demonstrated multiple ignition system will provide the flexibility of liquid systems without sacrificing the reliability and simplicity of solid motors.

The toroidal motor has a variable-area nozzle coupled to a pressure-sensitive grain. The propellant changes its burning rate with chamber pressure.

A moveable pintle located in the center of the torus forms the inner surface of the variable-area throat while the outer surface is formed by a shroud attached to the chamber wall.

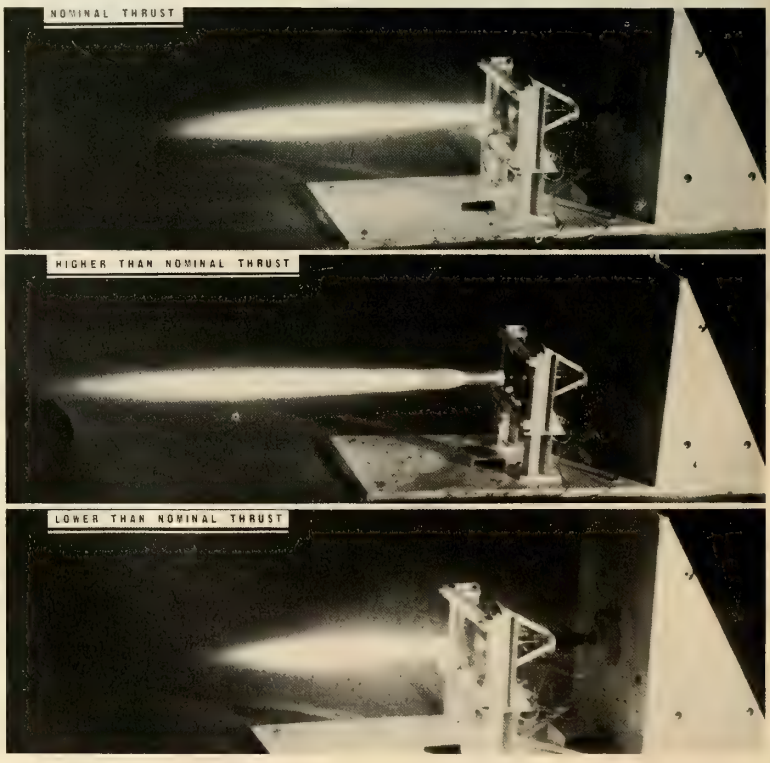
- **Immediate TVC**—In operation, the pintle is moved back and forth by a hydraulic actuator also located in the center of the motor—providing controlled throat area variation with consequent thrust control. The hot gases are discharged from the chamber's center surface through a circular opening running continuously around the torus hole.

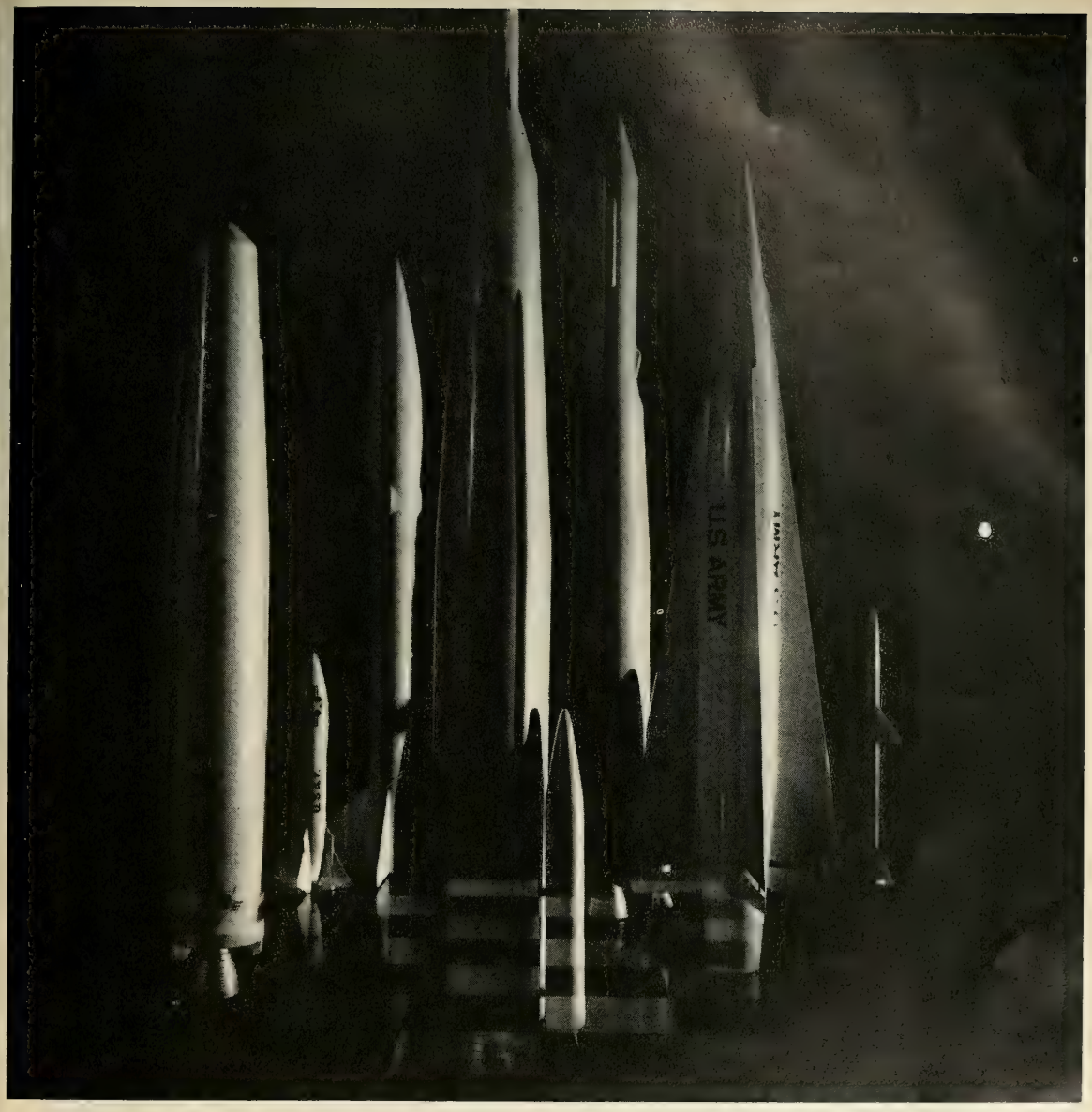
When the pintle or plug is extended to its full length, the motor operates at full thrust. As it is withdrawn, the throat area increases, reducing the pressure of the burning toroidal grain with a resultant reduction in thrust.

Quick removal of the pintle sharply reduces the chamber pressure and halts combustion immediately.

The toroidal shape was initially chosen because it is ideal for mounting the pintle and its actuation system out of the hot gas environment of the combustion chamber. The lightweight thrust modulation components will be used in subsequent firings. ■

THREE DIFFERENT thrust levels generated in a controlled 10-second firing at Aerojet-General's Sacramento plant.





Missile chess

This may be the world's most serious game. Our ability to play it well can be the difference between whether we live in our own free world or behind someone else's walls.

So in Douglas laboratories, researchers are working on making missiles invisible to detecting devices. Every advance they make is communicated to another group of Douglas engineers and scientists engaged in developing systems that seek out and destroy "invisible" missiles. When the second group succeeds, those employed in hiding missiles in the sky go to work again to break the checkmate.

Continuous improvement takes place...a basic requirement if the U.S. is to maintain leadership in missile technology.

The Douglas approach grows out of experience gained in producing a greater number and diversity of missiles than any other company. These include such great performers as *Thor, Hercules, Sparrow, Genie* and *Zeus*.

DOUGLAS

MISSILE AND SPACE SYSTEMS DIVISION

Engineering career opportunities

Tie your career to the world's most advanced radar/sonar systems... at G.E.!

Investigate your career now in missile-defense radar; advanced sonar engineering at General Electric.

G.E.'s Heavy Military Electronics Dept.—whose capabilities include the design, development and fabrication of the world's largest and most advanced ASW and radar systems—announces long-term career openings for continuing contributions to large military contracts.

HMED offers you stability based on its broad capability for handling large programs and the experience that goes with front-rank performance on this decade's most advanced projects. Your growth is tied to that of a lean, highly professional engineering group backed by top-flight facilities—both within HMED and throughout General Electric.

At G.E., you'll be treated as a professional who's expected to handle well-defined, delegated responsibility. In most instances you'll deal directly with your customer's organization.

You will be given every opportunity to develop yourself professionally through continuing Company-taught courses and advanced tuition-paid study at nearby Syracuse University. And, in the course of your work, you'll have access to information developed by other G.E. facilities throughout the country.

WHY NOT MATCH YOUR EXPERIENCE AND CAREER DESIRES AGAINST THESE REQUIREMENTS?

SONAR: Advanced Sonar Engineers; Array Beamformer and Signal Processing Development Engineers; Digital Logic Engineers; Sonar Solid-state Circuit Design; Transducer Development; Solid-state Transmitter Development; Pattern Recognition Analysis; Adaptive Filtering Research; Display Development; Propagation Analysis; Sonar Subsystem Development.

RADAR: Monitor and Control Analysis Engineers; Digital Control Eqpt. Engineers; Microwave Component Design Engineers; Consultant, Circuit Design and Development; Instrumentation Circuit Engineers; ME's for Signal Processing Modules; Consultant, Array Radar Subsystem Requirements.

INVESTIGATE NOW! For full information, send a resume of your experience in confidence to J. L. Wool, Professional Placement, Heavy Military Electronics Dept., Section 110, General Electric Co., Court St., Syracuse, New York.

177-65

An Equal Opportunity Employer

GENERAL ELECTRIC

The Industry Week

Mergers and Acquisitions

Vernitron Corp., Farmingdale, N.Y., has acquired the magnetic components product line formerly manufactured by Giannini Controls Corp. The acquisition includes designs, tooling and inventory for Giannini's line of torquers, signal generators, synchros, resolvers and custom-designed servo motors. . . . *Simmonds Precision Products, Inc., Tarrytown, N.Y., has bought 271,413 shares of Liquidometer Corp. stock. Price was $9.50 per share and the purchase represents 53% of the shares outstanding. Simmonds also made known the fact that it plans to make another offer within 6 months to purchase the remaining shares of Liquidometer.*... Crane Co. of New York City has acquired the Chempump Div. of Fostoria Corp. The Warrington, Pa., division, which makes pumps capable of handling acids, caustics and toxic materials, will operate as a division of Crane. . . . *Itek Corp. of Lexington, Mass., has signed an agreement to sell to Time, Inc., 60,000 shares of common stock for $2,010,000 as an investment. If the deal is approved by the Time board of directors, Itek will use the funds to build a new building and for working capital. Itek, with divisions in Palo Alto, Calif., Rochester, N.Y., and Osining, N.Y., is active in the areas of optical systems and reconnaissance, reproduction equipment and supplies, photo-optical storage and computing, and graphic data processing.* . . . Callins Industries, Greenfield, Tenn., has purchased the assets of the International Electronic Industries Div. of Standard Pressed Steel Co. of Jenkintown, Pa. Callins, a subsidiary of Whitehall Electronic Corp. of Dallas, makes electronic components; IEI manufactures a line of miniature electrolytic capacitors.

New Activities

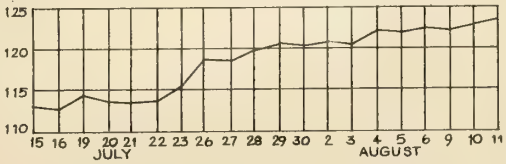
Fairchild Semiconductor, Mountain View, Calif., has begun work on a facilities expansion at its transistor and microcircuit fabrication plant in South Portland, Me. The addition will more than triple the size of the present 46,000-sq.-ft. facility. Fairchild Semiconductor has also announced plans to build a manufacturing plant on the Navajo Indian Reservation in Arizona. . . . *The Martin Co. has dedicated a Research Institute for Advanced Studies in Baltimore. The 43,000-sq.-ft. RIAS building provides for some 100 scientists and technicians working in basic research in the fields of physics, metallurgy, bioscience and control theory. The company has also begun construction of a new guidance system development laboratory in Orlando, Fla. The lab is to be used in the development of new optical and radiation-seeking guidance systems for advanced tactical missiles. The lab will be capable of simulating real-time flight conditions so successfully that the number of flight tests of the missiles will be significantly reduced, according to Martin.* . . . IIT Research Institute is establishing a center in Chicago to coordinate its activities in the evaluation of materials. The facility, to be called the IITRI Materials Evaluation Center, will be concerned with the measurement of mechanical, thermophysical and other properties of metallic, inorganic, and polymer materials under conditions including temperatures from the cryogenic range to 6,000° F. . . . *Sensonics, Inc., has moved to new, larger offices in Wheaton, Md. The company makes and markets transducers, amplifiers, and associated electronics equipment.* . . . Ocean Space Services, Inc., has moved its offices and manufacturing facilities from Annapolis to a new 6,000-sq.-ft. building in Rockville, Md. OSS specializes in oceanographic exploration equipment. . . . *Polyurethane Products, Inc., St. Louis, Mo., a firm specializing in the continuous molding of rigid urethane foam, has opened a new 50,000-sq.-ft. plant in East St. Louis, Ill.*

International

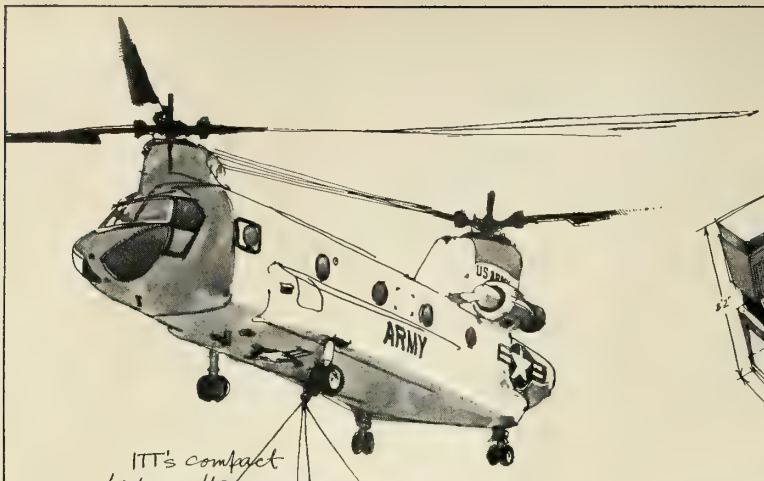
Aerojet-General Corp. has announced the merger of its ITADCO Div. and its International Operations under the ITADCO name. The organization will employ Aerojet capabilities to assist the development of emerging countries. The combined group will be directed from corporate headquarters in El Monte, Calif. . . . *C-E-I-R, Inc., Arlington, Va., and the Puerto Rico Industrial Development Co. have joined in the formation of a research and computer services company in San Juan. C-E-I-R will own a 60% interest in the new enterprise, which will be known as Management Sciences International.* . . . Parker-Hannifin Corp., Cleveland, and R. E. Jeffries, Pty. Ltd., of Sydney, Australia, have formed a jointly owned company, Jeffries Parker Hannifin, Ltd., to utilize Jeffries Sydney facilities in the manufacture of P-H's products. P-H makes fluid system components for industry, aerospace and consumer durable goods markets.

Missile/Space Stock Index

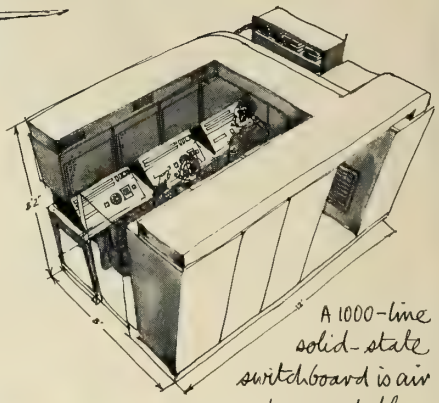
The President's request for an additional $1.7 billion to cover costs of the stepped up pace of the war in Viet Nam coupled with discussion of a large supplemental request to follow in January caused a considerable upsurge in defense stocks last week. The Missile/Space Stock Index reached 123 for the first time.



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH



ITT's compact troposcatter field unit AN/TRC 112 is in full operation 30 minutes after landing



A 1000-line solid-state switchboard is air transportable.

AN/TPN-8 tactical GCA system weighs only 1,140 lb.

Fight light!

Limited Warfare's First Rule.
Hit and run tactics in today's limited wars, particularly where guerrilla activity exists, call for lightweight but rugged equipment. The kind that can be moved in, set up and moved out in a matter of minutes. For example:

ITT's troposcatter communications field unit is on the air 30 minutes after transport to map coordinates. Called the AN/TRC-112, it's capable of simultaneous multichannel operation with duplex, telephone, teleprinter, photofacsimile, and data link equipment.

Suppose you need a complete telephone switchboard up in the hills fast? Call for ITT's air transported CSE-11. This 1000-line, 110-trunk unit is completely solid state. Only 12' long by 8' wide, CSE-11 takes 1/10 the space and 1/2 the power of comparable switchboards.

How about a tactical GCA radar that goes to work within one hour? AN/TPN-8 is it. Transport it by helicopter or truck to forward airstrips for precision range, azimuth and elevation information. Developed by ITT Gilfillan, AN/TPN-8 is ready for delivery.

And so it is with a wide range of ITT limited warfare devices—tactical displays, man-pack communications, DME ground beacons—they're designed to move.

International Telephone and Telegraph Corporation, New York, New York.

THESE ITT COMPANIES ARE ACTIVELY SERVING U.S. DEFENSE AND SPACE PROGRAMS: FEDERAL ELECTRIC CORPORATION • ITT ARKANSAS DIVISION • ITT CANNON ELECTRIC DIVISION • ITT DATA AND INFORMATION SYSTEMS DIVISION ITT ELECTRON TUBE DIVISION • ITT FEDERAL LABORATORIES • ITT GENERAL CONTROLS DIVISION • ITT GILFILLAN INC. • ITT INDUSTRIAL LABORATORIES DIVISION • ITT INDUSTRIAL PRODUCTS DIVISION • ITT SEMICONDUCTORS DIVISION • ITT WIRE AND CABLE DIVISION • ITT WORLD COMMUNICATIONS INC. • JENNINGS RADIO MFG. CORP.

ITT

contracts

AIR FORCE

$21,196,830—**TRW, Inc.,** Redondo Beach, Calif., for *Minuteman* support services and space ground communications.

$10,000,000—**Air Products & Chemicals, Inc.,** Allentown, Pa., for a three-year contract to maintain and operate five liquid oxygen and liquid nitrogen production facilities in California, Colorado and Florida.

$4,462,000—**The Boeing Co.,** Seattle, to modernize *Minuteman* weapons system.

$3,593,000—**Aerojet-General Corp.,** Sacramento, Calif., to test missile propulsion systems.

$3,251,701—**General Telephone & Electronics Corp.,** Sylvania Electric Products, Inc., Mountain View, Calif., to provide spare parts for electronic data-processing equipment.

$3,195,500—**Thiokol Chemical Corp.,** Brigham City, Utah, for a 156-in. fiberglass rocket motor.

$2,500,000—**General Motors Corp.,** Milwaukee, for work on inertial guidance systems.

$2,109,275—**Giddings & Lewis Machine Tool Co.,** Fond du Lac, Wis., for equipment for aircraft and missile factories.

$1,702,000—**Lockheed Aircraft Corp.,** Jamaica, N.Y., initial increment to a $3.9-million contract for modification and maintenance of surface-to-air missiles.

$1,350,606—**Lear Siegler, Inc.,** Grand Rapids, Mich., to make gyroscope assemblies and power amplifiers.

$1,291,540—**Lear Siegler, Inc.,** Santa Monica, Calif., for missile safety work.

$1,137,091—**Dow Chemical Co.,** Midland, Mich., for ordnance work.

$976,000—**Radio Corp. of America,** Missile and Surface Radar Div., Moorstown, N.J., for spares and services for radar equipment.

$758,000—**Radio Corp. of America,** Aerospace Systems Div., Burlington, Mass., for AN/TSQ-47 updating.

$603,195—**North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., for engineering services in support of the *Minuteman* weapon system.

$284,080—**Martin Marietta Corp.,** Baltimore, for repair and maintenance of CGM-13B missile inertial guidance system components.

$35,964—**Ryan Aeronautical Co.,** San Diego, Calif., for forward support assembly applicable to *BMQ-34A* target drone.

Goodyear Aerospace Corp., Akron, Ohio, to fabricate, erect and test a tracking antenna and protective radome for the BMEWS site at Clear, Alaska (amount not disclosed).

C-E-I-R, Inc., Arlington, Va., for continuing investigation into the use of mathematical computer programming techniques for the calculation of atomic wave functions (amount not disclosed).

ARMY

$9,975,000—**American Telephone & Telegraph Co.,** Western Electric Co., New York City, for modification kits for *Hercules* missiles.

$5,942,288—**Eastman Kodak Co.,** Rochester, N.Y., for propellants and explosives.

$2,945,372—**Weatherhead Co.,** Cleveland, Ohio, for antitank projectiles.

$1,672,375—**Laboratory For Electronics,** Waltham, Mass., for airborne receivers.

$1,513,372—**Hughes Aircraft Co.,** Culver City, Calif., for final funding action of single anticipated overrun, *TOW*.

$962,981—**Northrop Corp.,** Newbury Park, Calif., for *AQM 38A* guided missile target services.

$481,522—**Thiokol Chemical Corp.,** Ogden, Utah, for rocket launchers.

$271,671—**Hughes Aircraft Co.,** Fullerton, Calif., for additional work, *SAM-D* component verification.

$250,000—**Sperry Rand Corp.,** Salt Lake City, Utah, for *Sergeant* missile system.

$230,000—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., to develop equipment which permits high-resolution real-time radar photography or display.

$73,687—**GCA Corp.,** GCA Technology Div., Bedford, Mass., for design, fabrication, integration, testing and delivery of two sounding rocket payloads.

$50,207—**Sperry Rand Corp.,** Salt Lake City, Utah, for concurrent repair parts for *Sergeant* missile system.

$30,376—**Belock Instrument Corp.,** College Point, N.Y., for technical representative services on *Hawk* simulator station for month of August.

$28,586—**Hughes Aircraft Co.,** Fullerton, Calif., for replenishment of spare parts.

NAVY

$88,318,048—**Lockheed Aircraft Corp.,** Burbank, Calif., to produce *Polaris A-3* missiles.

$23,597,250—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for engineering associated with *Polaris A-3*.

$9,000,000—**Lockheed Aircraft Corp.,** Sunnyvale, Calif., for classified work on the *Polaris* missile system.

$6,500,000—**Radio Corp. of America,** Communications Systems Div., Camden, N.J., for a classified program.

$4,846,237—**General Electric Co.,** Pittsfield, Mass., to modify fire-control systems.

$3,899,939—**Aerojet-General Corp.,** Azusa, Calif., for torpedoes.

$2,272,419—**Interstate Electronics Corp.,** Anaheim, Calif., to test instrumentation of the *Polaris* weapons system.

$2,013,862—**American Machine & Foundry Corp.,** York, Pa., for liquid-propellant rocket engines.

$2,009,400—**Chromcraft Corp.,** St. Louis, for LAU-3A rocket launchers.

$1,532,425—**Varian Associates,** Palo Alto, Calif., for microwave linear accelerator.

$570,000—**International Telephone & Telegraph Corp.,** ITT Gilfillan, Inc., Los Angeles, for production and delivery of AN/TPN-8 radar sets.

$296,000—**General Electric Co.,** Pittsfield, Mass., for engineering consultation services on *Polaris* fire control system.

$224,000—**Radiation Systems, Inc.,** Alexandria, Va., for further development of subsystems for the *Shrike* missile.

$183,574—**Edwin A. Keeble Associates, Inc.,** Nashville, Tenn., for preparation of logistics information in support of maintenance and production of surface missile system.

$144,761—**Atlantic Research Corp.,** Alexandria, Va., for research and development in the field of solid propellants.

$73,780—**Value Engineering Co.,** Alexandria, Va., for value engineering services for missile propulsion systems.

$22,500—**Hercules Powder Co.,** Wilmington, Del., for expansion of rocket motor production.

$22,000—**Bissett-Berman Corp.,** Santa Monica, Calif., to continue its applied mathematical analyses of ocean mixing, with the objective of determining the extent to which ocean dynamics are influenced by random causes.

NASA

$1,000,000—**Bissett-Berman Corp.,** Santa Monica, Calif., to conduct analyses studies to estimate the influence of mission profiles, proposed hardware and data-handling procedures on the errors in the predication of the trajectory of *Apollo* mission spacecraft.

$969,000—**Chaney and James Construction Co., Inc.,** Richardson, Tex., for gas storage and distribution system at Marshall Space Flight Center.

$478,083—**North American Aviation, Inc.,** Rocketdyne Div., Canoga Park, Calif., for evaluation and demonstration of the use of cryogenic propellants for reaction control systems.

$429,200—**Lockheed Aircraft Corp.,** Missiles and Space Co., Sunnyvale, Calif., for lunar orbiter shroud systems, modifications, testing and final preparations for flight.

$428,000—**Lockheed Aircraft Corp.,** Missiles and Space Co., Sunnyvale, Calif., for *Agena* long-shroud qualification program.

$388,643—**United Aircraft Corp.,** Pratt & Whitney Div., East Hartford, Conn., to develop compressor end seals and stator pivot seals in advanced air-breathing porpulsion systems.

$372,544—**General Electric Co.,** Vallecitos Atomic Laboratory, Pleasanton, Calif., for diode, fuel-clad and insulating testing.

$350,000—**Arthur D. Little, Inc.,** Cambridge, Mass., for analytical and experimental studies leading to the establishment of design criteria for stable performance of liquid-propellant rocket engines.

$299,860—**Hughes Aircraft Corp.,** Research Laboratories, Malibu, Calif., for development of linear-strip ion thrustor.

$267,652—**United Aircraft Corp.,** Pratt & Whitney Div., East Hartford, Conn., to develop man-shaft systems.

$256,091—**The Bendix Corp.,** Research Laboratory, Southfield, Mich., for all-fluid amplifier development for liquid rocket secondary-injection thrust vector control.

$240,000—**Radio Corp. of America,** Astro-Electronics Div., Princeton, N.J., for a TV scan converter.

$226,223—**TRW Inc.,** TRW Equipment Laboratories, Cleveland, for receiver/heat storage unit development program.

$206,798—**Electronic Associates, Inc.,** West Long Branch, N.J., for services and material to maintain, repair and test analog computer systems.

$161,000—**The Dow Chemical Co.,** Midland, Mich., for nine-month study to determine an improved method for *Apollo* propellant system decontamination and propellant tank drying.

$142,331—**North American Aviation, Inc.,** Atomics International Div., Canoga Park, Calif., for fuel assembly temperature coefficient of reactivity investigation.

$132,680—**United Aircraft Corp.,** Pratt & Whitney Div., West Palm Beach, Fla., for advanced bearing study.

$99,977—**Douglas Aircraft Co.,** Santa Monica, Calif., for study of head and steering for simplified manned space vehicle.

$88,625—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., to conduct a 19-month program to synthesize ferrohydrodynamic fluids and to characterize their physical, chemical and magnetic properties.

$88,116—**University of California,** Berkeley, for investigation of ion sputtering.

$87,677—**American Radiator,** Research Div., New Brunswick, N.J., for an experimental investigation of a magnetoplasmadynamic power duct.

$81,604—**General Electric Co.,** Philadelphia, for analytical study of thermal integration of dynamic powerplants and life-support subsystems of a lunar roving vehicle.

$77,760—**Western Electric Co.,** New York City, for reduction and analysis of radiation data.

$74,213—**Control Data Corp.,** Minneapolis, for scanning electrical attitude determination system.

$72,219—**General Electric Co.,** Philadelphia, for a research program to demonstrate feasibility of assembly/sterilizer facility.

INDUSTRY

$35,158,122—**General Tire and Rubber Co.,** Aerojet-General Corp., El Monte, Calif., from **Lockheed Aircraft Corp.,** Burbank, Calif., for production of *Polaris A-3* missiles.

$14,065,275—**Hercules Powder Co.,** Wilmington, Del., from **Lockheed Aircraft Corp.,** Burbank, Calif., for production of *Polaris A-3* missiles.

$3,000,000—**General Electric Co.,** Winston-Salem, N.C., from **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for a unique control system to be used in LEM.

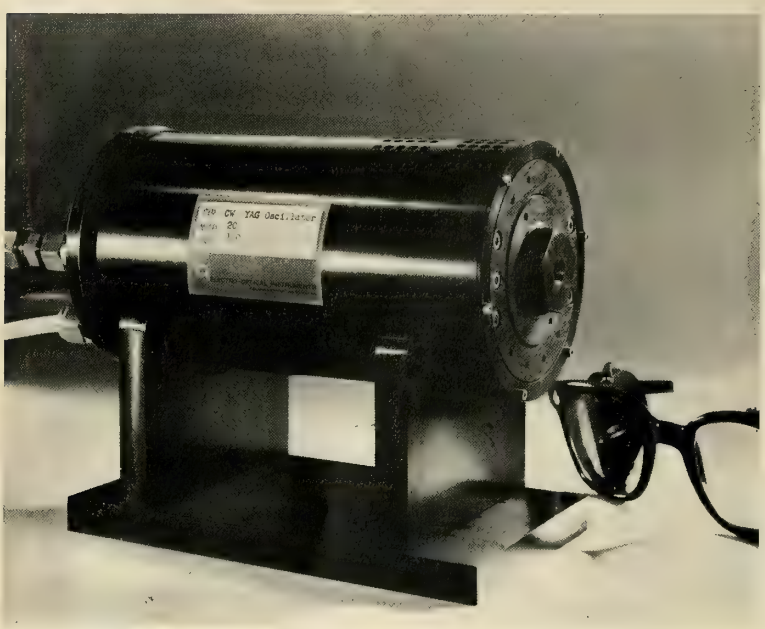
$700,000—**Electro Development Corp.,** Seattle, from **The Boeing Co.,** Seattle, to supply electronic equipment for use in the first stage of *Saturn V*.

$600,000—**Saginaw Products Corp.,** Saginaw, Mich., from **The Boeing Co.,** Seattle, to supply electromechanical actuators used on *Minuteman* launch control center access doors.

$110,000—**Aluminum Co. of America,** Layfayette, Ind., from **The Boeing Co.,** Seattle, to supply a number of electronic cabinet extrusions used in *Minuteman* launch facilities and launch control centers.

$17,900—**Simmonds Precision Products, Inc.,** Tarrytown, N.Y., from **United Aircraft Corp.,** Hamilton Standard Div., Windsor Locks, Conn., to develop a system for measuring the amount of water available in the Project *Apollo* portable life support system.

Ryan Aeronautical Co., San Diego, from **California Institute of Technology,** Jet Propulsion Laboratory, Pasadena, Calif., to develop a unique flexible solar array to capture the Sun's energy for space vehicles (amount not disclosed).



New Product of the Week: Laser Oscillator

A continuous-wave laser oscillator with a peak power output of 0.88 watts at 1.06 microns is being marketed by Electro-Optical Systems, Inc.'s Instruments Div.

The Model 20 weighs 6 lbs. and operates at room temperature. It employs a yittrium aluminum garnet laser rod doped with neodymium and is designed to simultaneously emit spike-free radiation from both ends of the cavity. The rod is cooled by circulating water. Pump power is supplied to the 3 x 50-mm laser rod by two tungsten-iodine lamps in air-cooled reflective cavaties. Lamp life is more than 50 hours at 0.5-watt output.

A standard variable transformer can be used to continuously vary laser output power by increasing input to 2,000 watts at 125v ac maximum. Lasing threshold is at 700 watts input.

Circle No. 151 on Subscriber Service Card

Synchronizer/Analyzer

A self-contained bit synchronizer analyzer that requires no external test equipment has been developed by Defense Electronics, Inc., Rockville, Md.

The Model BA-101 measures and displays bit error rate and sync acquisition time directly on a decimal display. It can accept bit rates from 1.2 bps to 1.2 mb. Variable signal-to-noise ratio from −10 db to 20 db is selectable along with transition density of 1:2 to 1:64.

Circle No. 152 on Subscriber Service Card

Glass-to-Metal Seals

Colonial Precision Industries, Inc., has announced a line of glass-to-metal seals designed for vacuum-tight connection between glass and metal tubing.

The seals are fabricated by actual fusion between the glass and metal materials. Series 500 glass-to-Kovar seals are available in eight o.d. sizes (⅛ through 1 in.). Glass-to-copper Series 400 seals are available in 12 o.d. sizes (⅛ through 2 in.). Overall standard length is 6 in. with tubing lengths of 1.5 in., for Kovar, and 3 in., for copper. Other sizes and configurations are available on order.

Circle No. 153 on Subscriber Service Card

Spray Chamber

A controlled-atmosphere chamber for plasma spraying of oxygen-sensitive or toxic materials is being marketed by Giannini Scientific Corp.'s Plasmadyne Div.

The unit measures 30 in. in diameter and 40 in. long and is designed to withstand vacuum. In operation, the plasma spray gun, powder hopper and part to be sprayed are inserted in the chamber. The chamber is then purged of air by use of a straight argon gas flow or a vacuum pump for outgassing.

The device offers four accessory items: a gas recirculation system; a vacuum transfer chamber; automatic handling equipment and a hyperthermal test section.

Circle No. 154 on Subscriber Service Card

Radiation Source

Giannini Scientific Corp. is marketing the Vortex Stabilized Radiation Source®, a high-pressure arc system designed to produce intense radiation in the ultraviolet, invisible and infrared portions of the spectrum.

In operation, radiation is produced by a d-c arc between water-cooled refractory metal electrodes in an inert-gas chamber. The inert gas is injected into the arc chamber in vortex flow, which repeatedly positions the arc relative to the electrodes. By maintaining a cool gas sheath around the arc, the vortex flow forces the arc current to flow within a defined cylindrical volume, typically 3 mm. in diameter by 10 mm. long for a 25-kw source.

Combined current and gas flow produces nearly uniform radiance along the length of the arc, averaging 2,500 watts/cm² steradian at 25-kw input using argon. The VSRS features a radiating solid angle of 10 steradians. Standard systems are available rated at 5, 10 and 25-kw input power. Units have been operated at input levels up to 150 kw.

Circle No. 155 on Subscriber Service Card

Rectilinear Potentiometer

Mektron Div. of California General, Inc., is marketing a series of rectilinear potentiometers which feature 50% fewer parts.

The PR1 series is designed to reduce the over all number of parts to six major assemblies. The units offer a 500% safety factor. All models incorporate a 0.050 mechanical over-travel and may be obtained with a 0.250 to 6.00-in. mechanical travel. Resistance values range from 2 to 20,000 ohms per inch. Independent linearity is 0.5% with resolutions available from 0.006 to 0.0008. Operating temperature range is −40° to 300°F.

Circle No. 156 on Subscriber Service Card

Silicone Rubber

Two silicone rubbers, designed for increased resiliency and abrasion resistance, have been developed by Dow

Corning Corp. for aerospace seal applications.

Bashore tests show 50% rebound for Silastic 55U rubber and 39% for Silastic 955U rubber. Abrasion tests run according to ASTM D1630 on 55U rubber show ratings up to 800—several times as high as comparable previous materials, the firm said. Low-temperature brittle point is —115°F. In tests at 24 hours at 350°F, it shows compression values of about 38%. In oil resistance tests, 55U showed a swell of 5% after 70 hours at 300°F in ASTM No. 1 oil.

Silastic 955U is designed specifically for service at very low temperatures and has a brittle point of —178°F.

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Resistor Networks

Microtek Electronics, Inc., has developed a line of thick-film resistor networks in the 10-ohm to 1-megohm range.

Typical temperature coefficients of 50 to 250 ppm/°C will track within ±1% from —70° to 150°C. The units are fired at high temperatures on 1-in.-

sq. or smaller alumina substrates. The network is then glass-passivated to extend performance life. The networks can withstand instantaneous temperatures up to 500°C without significant permanent damage. Tolerances are ±10%, ±5% and ±1% with power ratings of 15 watts/square inch of material.

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Multicoupler

Vitro Electronics, a division of Vitro Corp. of America, is marketing the Typel MC-106 multicoupler with a passband of 250 to 500 mc.

The device provides a dynamic range to 0 dbm. Intermodulation is better than 40 db down with 0 dbm inputs. The input circuit will withstand a 10-v continuous input without permanent damage and will withstand inpulse voltages up to 100v. The output network provides eight 50-ohm outputs, isolated from each other by a minimum of 55 db. The unit requires 3.5 in. of vertical rack space.

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HERCULES

Safe Way to the Surface

Present-day deep-running submarines have brought an increased need for an effective method of escape in critical situations. Long concerned with this problem, the survival system branch of the U.S. Naval Applied Science Laboratory joined Hercules engineers in developing an escape capsule capable of withstanding severe pressures during ascent.

Pioneers in development of rocket motor cases made from Spiralloy® filament-wound glass fibers, Hercules utilized the same material in the escape capsule shown here. The material when properly formed provides a structure lighter than aluminum and stronger than steel.

Hercules technology speaks for itself. Our engineers have been instrumental in many of our country's technological breakthroughs both large and small. To be part of this outstanding team requires only that you are qualified. Address career inquiries to Manager, Technical Recruitment, Explosives & Chemical Propulsion Department....

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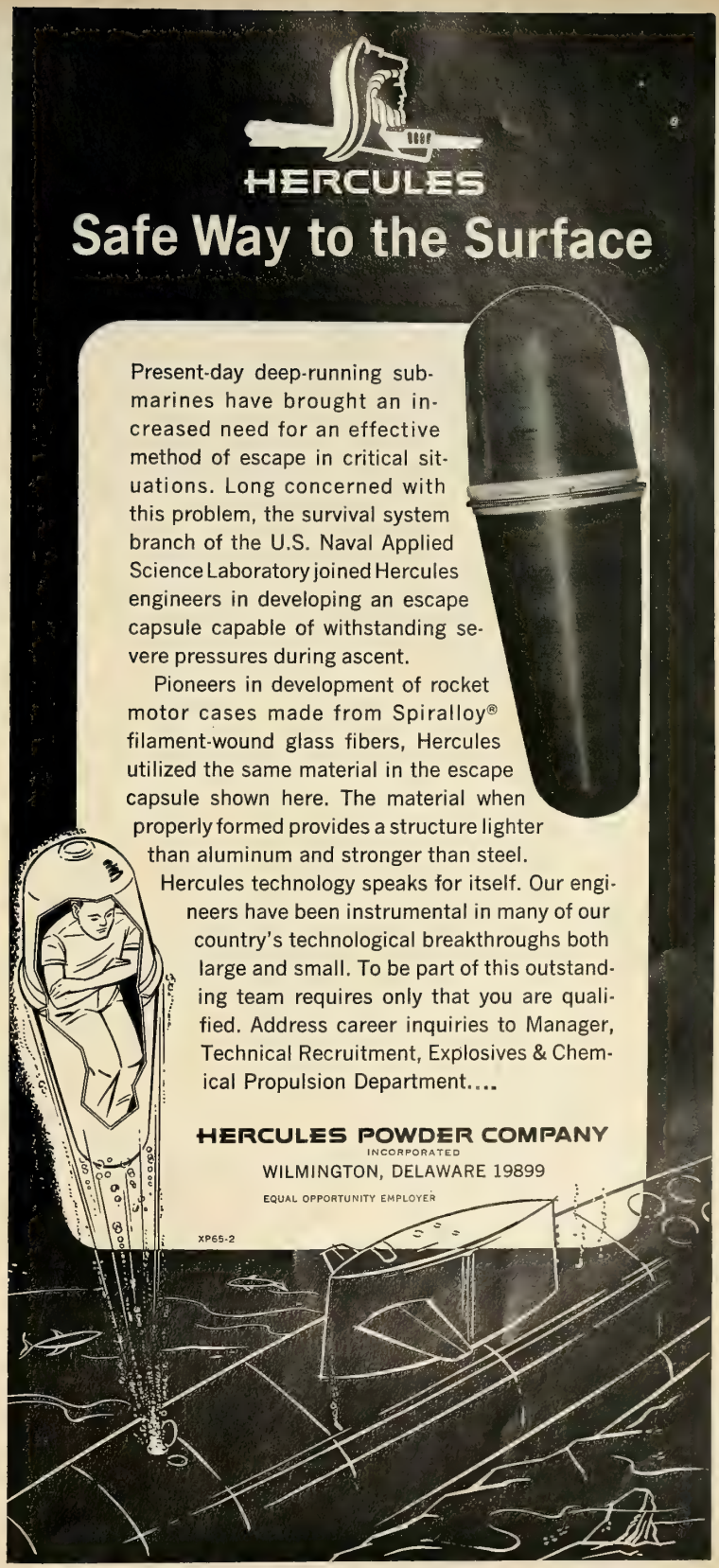

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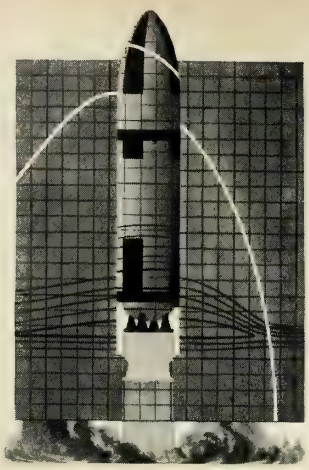

LOOK AT LOCKHEED...IN AEROMECHANICS

At Lockheed Missiles & Space Company, Aeromechanics encompasses many diversified technologies. Typical areas of research and development include:

THERMODYNAMICS—Ascent and entry aerodynamic heating, fluid mechanics, thermodynamics of propulsion devices and cryogenic propellants, and thermal characteristics of materials.

AERODYNAMICS—Rarefied and continuum aerodynamics, gas dynamics, hydrodynamics and external fluid dynamics, engineering mechanics.

STRUCTURAL DYNAMICS—Basic loads, environments, structural criteria, aero-elasticity, shock, vibration, acoustics, and structural feedback functions for analysis of controls stability.

Scientists and engineers in these disciplines at Lockheed have already made significant contributions to such major projects as the POLARIS Fleet Ballistic Missile and the AGENA booster/satellite. Candidates with advanced degrees: Accept this opportunity to make *your* contribution to more advanced missiles, space, entry and hydrodynamic vehicle systems. Address: Lockheed Missiles & Space Company, Dept. 530, P. O. Box F504, Sunnyvale, California.

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Joseph E. Muckley: Elected to the board of directors of Martin Marietta Corp. He is vice president and chief financial officer of the corporation. Also elected to the board was **William B. Bergen.** He is a vice president of the corporation and president of the aerospace division of Martin Co.

Richard W. Forsythe: Appointed manager of Rocket Research Corp.'s Eastern Office, Hyattsville, Md. He was formerly head of mechanical engineering for Electro-Mechanical Research, Inc., College Park, Md.

Dr. Arthur M. Bueche: Elected vice president of the newly formed General Electric Research and Development Center. He was formerly manager of chemistry research at the Research Laboratory, which was combined with the Advanced Technology Laboratories to form the new division.

Dr. Roscoe Bartlett: Named to head the new Space Life Sciences Group of The Johns Hopkins University Applied Physics Laboratory.

Eugene E. Leist: Named manager of Aerojet-General Corp's. Mark 46 torpedo testing operations at the U.S. Navy Torpedo Station.

Robert M. Beck: Appointed executive vice president of Scientific Data Systems. He is one of the co-founders of the company.

Jack S. Parker: Elected a term trustee of Rensselaer Polytechnic Institute. He was elected for a four-year term. He is a vice president and group executive of General Electric Co.

Jack T. Bradley: Appointed a vice president of Northrop Corp.'s International Div. He is director of international service of the Aerospace Industries Assn.

Dr. Richard A. Stasior: Became manager of application engineering for the Syracuse unit of General Electric's Semiconductor Products Dept.

Dr. Paul D. Greenberg: Appointed department head of System Development Corp.'s Defense Systems Div., operational systems group. Also appointed department heads were **Robert W. Hamer,** field operations; **Dr. Guy G. Besnard,** training systems; and **Dr. Leroy S. Burwen,** system training extensions.

Dr. Richard Zipin: Appointed as a research associate at the National Bureau of Standards for one year to assist in laser research for precision measurement and length standards He is with Sheffield Corp.

Joseph L. Gillman, Jr.: Named to the board of directors of Washington Technological Associates, Inc. He is president of the consulting engineering firm of Joseph Gillman Associates.

George L. Schafstall: Appointed vice president-controller of Avco Corp.'s Aerospace Structures Div. He formerly held the same position with the Ordnance Div. of Avco.

Orville D. Reed: Elected chairman of the Washington Section of the American Astronautical Society. He is with Thiokol Chemical Corp.

Gen. Curtis E. LeMay (USAF-Ret.): Assumed the office of president of the Air Force Historical Foundation.

Gen. Mark E. Bradley, Jr. (USAF-Ret.): Joined The Garrett Corp. as assistant to the president.

James V. Bitner: Elected a corporate vice president of Lear Siegler Inc. He is president of LSI's Instrument Div. Also elected corporate vice presidents were **Harold J. Downes,** manager director of Lear Siegler International S.A., and **Richard W. Harbison,** president of Lear Siegler Service, Inc.

Starr J. Colby: Will be leaving the Department of Defense at the end of the month. He is assistant deputy director of Defense Research and Engineering for space technology. Replacing him will be **John Kirk** who was formerly associated with Massachusetts Institute of Technology.

Prof. Marcel Nicolet, Dr. Sydney Chapman and Dr. Joseph Kaplan: To be presented the Hodgkins prize and gold medal for their outstanding contributions to the field of atmospheric research during the second week of the Smithsonian Astrophysical Observatory's 75th Anniversary Celebration. This award has been given only twice before—once in 1899 to James Dewar, and once in 1902 to J. J. Thomson.

Edward M. LaCombe: Appointed manager of research and development of Union Carbide Corp.'s Silicones Div. Laboratory.

missiles and rockets

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AUGUST

Tenth Technical Symposium, sponsored by Society of Photo-optical Instrumentation Engineers and Air Force Systems Command, Jack Tar Hotel, San Francisco, Aug. 16-20.

1965 National Meeting of the American Astronautical Society, Sheraton Palace, San Francisco, Aug. 18-20.

International Conference on Energetics, sponsored by ASME, University of Rochester, Rochester, N.Y., Aug. 18-20.

International Lunar Geological Field Conference, sponsored by University of Oregon and New York Academy of Sciences, Bend, Ore., Aug. 22-28.

Sixth International Electronic Circuit Packaging Symposium, sponsored by Electrical Design News (concurrent with WESCON), San Francisco Hilton Hotel, San Francisco, Aug. 23-24.

Cryogenic Engineering Conference, sponsored by Cryogenic Society of America, Rice University, Houston, Aug. 23-26.

Conference on the Exploration of Mars and Venus, sponsored by Virginia Polytechnic Institute, NASA and Air Force Cambridge Research Laboratory, Blacksburg, Va., Aug. 23-27.

1965 Western Electronic Show and Convention (WESCON), San Francisco, Aug. 24-27.

Sixth Biennial Gas Dynamics Symposium, sponsored by American Institute of Aeronautics and Astronautics and Gas Dynamics Laboratory of Northwestern University, Northwestern University, Evanston, Ill., Aug. 25-27.

Annual Conference on Applications of X-ray Analysis, sponsored by Denver Research Institute, University of Denver, Albany Hotel, Denver, Aug. 25-27.

1965 International Symposium on Antennas and Propagation, sponsored by Institute of Electrical and Electronics Engineers, Sheraton Park Hotel, Washington, D.C. Aug. 30-Sept. 1.

Twelfth National Conference of the Armed Forces Management Assn., Washington Hilton Hotel, Washington, D.C., Aug. 31-Sept. 2.

SEPTEMBER

Second Annual Conference on the Effects of Shock and Vibration on the Human Body, sponsored by University of Denver and the Colorado Chapter of the Institute of Environmental Sciences, University of Denver, Denver, Sept. 1-3.

URSI Symposium on Electromagnetic Wave Theory, sponsored by U.S. National Committee, International Scientific Radio Union (URSI), Technological University of Delft, The Netherlands, Sept. 6-11.

XVIth International Astronautical Congress sponsored by the International Astronautical Federation, Athens, Greece, Sept. 12-18.

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A Twenty-Year Plan

AN IMAGINATIVE LOOK at the future by industry leaders attending the San Francisco meeting of the American Institute of Aeronautics and Astronautics outlined some strong challenges for the years ahead.

The boldest proposal came from Dr. Wernher von Braun, director of NASA's Marshall Space Flight Center, who urged that the U.S. undertake manned missions to Mars and Venus within the next 20 years.

These would include a one-way trip to Mars for a group of astronauts who would be picked up a year and a half later—"Congress willing," as Dr. von Braun jokingly put it.

Talk of space exploration in 1985 seems to have the far-out ring of science fiction. Yet it is easy to forget how fast 20 years slips past. Projects undertaken in 1945 have a direct bearing on our space capabilities today; projects set in motion this year will affect our space activities in 1985. This should be remembered as Dr. von Braun's remarks are analyzed.

He wants this nation to take advantage of the impetus of the *Apollo* manned lunar landing program to carry out four manned planetary missions using hardware already under development. These would include an American landing on Mars in 1982 and establishment of a Mars base in 1984-86.

The U.S. will have the capability of turning out six *Saturn V* and six *Saturn IB* vehicles a year in the post-*Apollo* period. The Marshall director's plans are aimed at putting this lift capability to work. The program also would employ the NERVA nuclear rocket engine now under development.

First major target beyond exploration of the Moon would be a three-man flyby of Venus in 1975—just ten years from now. This would involve orbital assembly employing four *Saturn V*'s in a logistics role. The flight with the S-II stage and spacecraft would take a year.

Next would come a manned flyby of Mars in 1978, a 682-day mission which would use the NERVA engine and require two supporting logistics launches.

The first Mars landing in 1982 would be a 20-day stay. The spacecraft would be propelled by five NERVA engines of 230,000 lbs. thrust each. It would include a Mars Excursion Module (MEM) and an Earth Entry Module (EEM). Eight astronauts would make the trip, with four descending in the MEM to the Martian surface on this preliminary visit.

MEM's entry into the thin Martian atmosphere would employ retrorockets and a braking parachute. Dr. von Braun says nothing discovered by *Mariner IV* has led him to regard this as an unacceptable technique.

The Mars base in 1984-86 would be manned by eight to 12 astronauts who would make the trip without a return stage. Six MEM's would be employed in establishing the base. The flight to pick up the Martian explorers would be made 18 months later, landing with two MEM's to lift the team back into orbit for rendezvous with the spacecraft and return to Earth.

The cost of this, according to Dr. von Braun, would be in the "same ballpark" as the *Apollo* lunar landing. He explains that by this he means the same percentage of gross national product, which is the way such expensive programs have to be measured.

The proposals have the advantage of using hardware adready being developed in the space program, one of the Administration's requirements for the immediate post-*Apollo* period.

Although these projects—particularly the Martian base proposal—may seem over-imaginative to the uninitiated, they are no more so than a program for Antarctic exploration would have appeared 20 years before its inception. Planning should begin now toward these goals. The outstanding performance of *Mariner IV* in returning amazingly detailed photographs of the Martian surface opened U.S. exploration of the Red Planet. Plans to follow up such unmanned visits with manned exploration should be given formal approval as soon as possible. To await conclusion of the *Apollo* lunar program before embarking on initial work towad manned planetary projects would be to waste time.

Dr. von Braun's version is coupled with a realistic appraisal of what can be accomplished with present hardware. His proposal deserves support. As *Apollo* funding peaks out, financial support should be provided for early work on the Mars and Venus flights.

AT THE SAME SYMPOSIUM, Dr. Arthur Kantrowitz, director of the Avco-Everett Research Laboratory, and Dr. Albert Hall, deputy director for space in the Directorate of Defense Research and Engineering, took a look at the future for military space programs.

Dr. Kantrowitz foresees such widespread civilian use of space satellites in 1985 that their destruction would affect the national economy. Therefore, they must be given military protection. He suggests that, by then, radiation weapons capable of striking great distances at the speed of light may be in use for this. These also might be employed in ballistic missile defense.

Dr. Hall, while hoping that space will not become a battleground, nevertheless believes the U.S. must be prepared against surprise. "We could no more go unprotected against the misuse of space than we would go unprotected on land, sea or in the air," he says.

We agree with these comments and we agree with Dr. Kantrowitz that one day we will regard the time wasted in approval of the *Manned Orbiting Laboratory* as shameful. The need for its capability in the years ahead is apparent.

The most delightful forecast at the meeting came, as it happened, from Dr. Simon Ramo of TRW. Maybe, he quipped, there will be a decision on *MOL* by 1985.

William J. Coughlin

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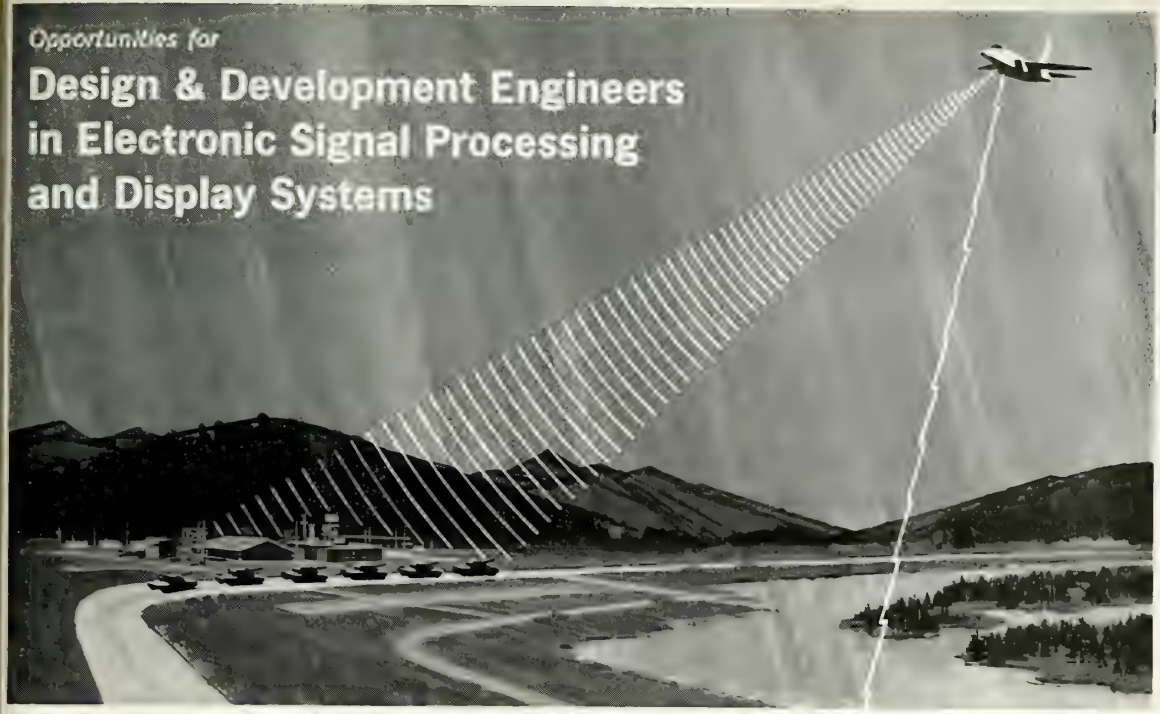

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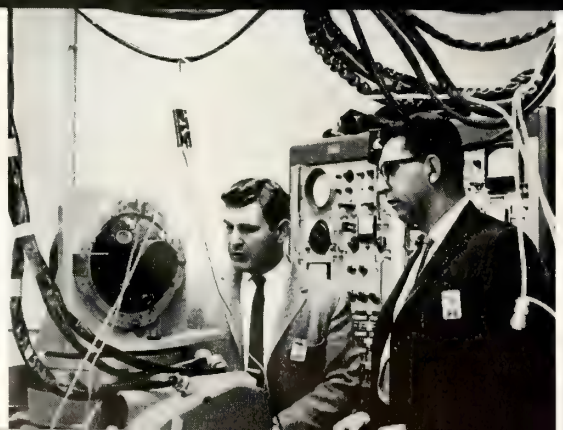

AUGUST 23, 1965

missiles and rockets

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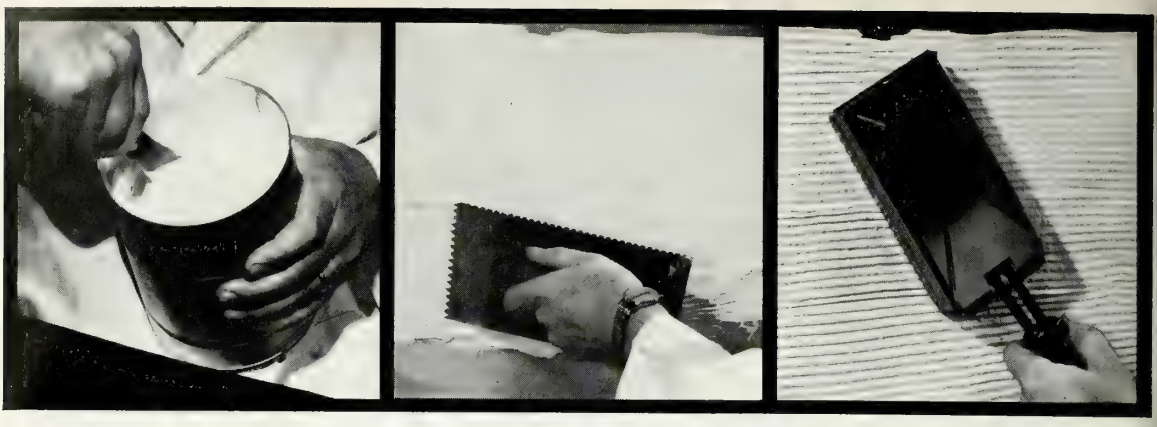

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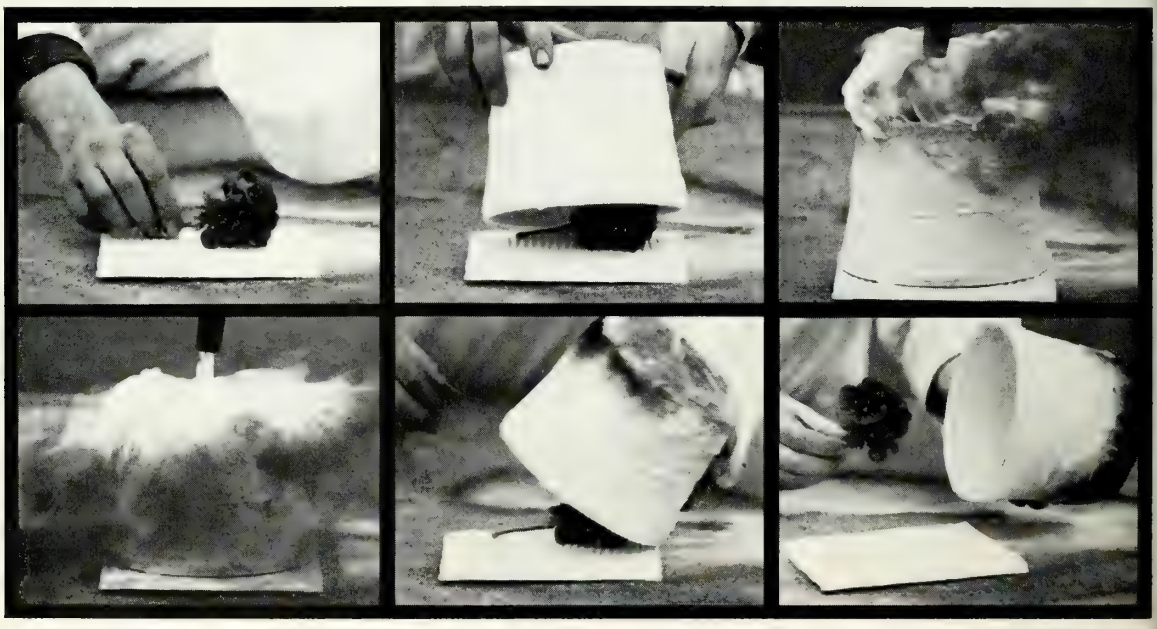

New flameproof RTV-757 Silicone Rubber withstands 5000°F for 60 seconds...and the flower doesn't even wilt!

Paint a thin layer of G-E RTV-757 on a paperboard carton. Subject it to a 5000°F flame for one minute. RTV-757 will not only prevent the paperboard from burning, but keep it cool inside (inside temperature will rise from 71°F to a modest 84°F).

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Volume 17, Number 8 August 23, 1965

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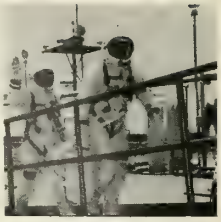

Astronauts Charles Conrad (left) and L. Gordon Cooper prepare to board Gemini 5 capsule before launch, which slipped past its originally scheduled Aug. 19 target date because of fuel cell and weather difficulties. An eight-day flight would give U.S. space edge. See p. 15.

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letters

Cryogenic Conference

To the Editor:

In the column "When and Where" of the Aug. 2 issue (p. 45), there is an announcement about the Cryogenic Engineering Conference to be held at Rice University in Houston Aug. 23-26. This announcement wrongly states that the Conference is sponsored by the Cryogenic Society of America. The Conference is a strong, viable organization with a decade of history which operates itself under the Secretaryship of Dr. K. D. Timmerhaus.

The Cryogenic Society will also be in Houston the same week, but it will be there to sponsor the first annual Cryogenic Exposition, to be held at the Rice Hotel.

W. D. English
Chairman, Publicity Committee
Cryogenic Engineering Conference
Orange, Calif.

'No Time for Civilians'

To the Editor:

Bravo on your Aug. 9 editorial ("No Time for Civilians"). You are right. Every U.S. citizen should be a highly "qualified requestor" of the document "Public Opinion and Ballistic Missile Defense." However, I suppose that under "executive immunity" not even a Congressman can get reports originating in the executive branch.

C. Walker Putney
San Jose, Calif.

GT-4 Euphoria

To the Editor:

Appreciate very much the information you supplied under the heading "GT-4 Hatch and Calcium" (Letters, M/R, July 12, p. 5). Have you heard any news about the difficulty with the hatch? Dr. Charles A. Berry found no evidence in calcium depletion in McDivitt and White, as some of us had anticipated he would not.

I would like to comment on your note that "doctors at the Manned Space Flight Center say very definitely that there was no experience of euphoria during the flight." From all available information (audible, live and written) on Astronaut White's EVA, it would appear that the astronaut's merry attitude and reluctance to *get inside* when so ordered was certainly at best a symptomatic manifestation or an indication of a transitory subtle spell of euphoria in the opinion of many physicians. Euphoria is euphoria, whether it occurs on land, under the sea or in space! This is not quite the place for a dissertation on the mechanics of euphoria. Suffice it to say that, as practicing physicians we encounter cases of euphoria plain or masked and in various degrees more often in daily practice than is generally realized. Therefore, we were wondering what conclusive *medical* evidence presented itself to justify the above emphatic negative statement.

Physicians, active in diagnosis and treatment, are following with increasing interest the excellent work of their confrères at Houston and at Cape Kennedy. They do reserve the right to form opinions based on proper dissemination of knowledge. MISSILES AND ROCKETS is to be complimented in this direction.

Dr. Constantine Generales
Chairman, Section on
Space Medicine
Medical Society of the State
of New York
New York, N.Y.

Merchants of MOL

To the Editor:

In regard to your editorial of Aug. 16 ("A Twenty-Year Plan") and others, it is agreed that a *Manned Orbiting Laboratory (MOL)* is desirable as an advance in technology—operated by civilians as a NASA project.

The reasons for your tooting the horn for the Pentagon Militarists-Air Force in this area is not so obvious and should be made public, even at the possible risk of being called a "War Hawk" magazine.

John Savas
Canton, Ohio

Maxson's AQM-37A's

To the Editor:

Congratulations on the July 26th World Missile/Space Encyclopedia Issue. It is an interesting and useful reference volume.

Since I am associated with Maxson Electronics Corporation, I was particularly interested in the listings for the *Bullpup* missile and the *AQM-37A* missile target. The *Bullpup* listing is correct, but I was surprised to see Maxson omitted from the information under the *AQM-37A*. Although Beech developed the *AQM-37A*, Maxson has received a multi-year production contract.

Samuel H. Goldstein
Maxson Public Relations
Counsel
Great Neck, N.Y.

Reader Goldstein is correct. Actually, Maxson has been awarded two such contracts, totalling $14,400,000.—Ed.

Reprints of M/R Index

Reprints of the editorial index of articles appearing in MISSILES AND ROCKETS during the first six months of 1965 are available at no cost from:

Research Department
Missiles and Rockets
1001 Vermont Ave., NW
Washington, D.C. 20005

MICROELECTRONICS: Sperry shows the way

More reliability, performance, precision and lower costs—all in increasingly less space—these are the results of Sperry's work with microelectronics. In nearly every product area Sperry divisions are applying this new art . . . from automatic flight controls, to computers, to sonar systems.

A recent example is the microcircuit AN/ARN-78 Airborne Loran-C Receiver. This Sperry development put navigation Loran in the cockpit for the first time. Developed under USN funding by our Information & Communications Division, these new receivers are being delivered to the Air Force, and were picked by NASA for Apollo recovery aircraft.

In advanced avionics, Sperry—under the Program Management Group—is engaged in study programs on ILAAS and MARK II AVIONICS. Designs for these new systems will provide extremely reliable avionics of superior performance . . . and much of the electronics will be microcircuited. For commercial airlines, our Inertial Division has developed the SGN-10 Inertial Navigation System. Microelectronics again plays an important role in its design.

For precision close air support anywhere in the world, Sperry is currently developing "Instant" Loran-D for USAF and USA. This new mobile design will make an all-weather, day or night, tactical navigation system a reality for both ground and air vehicles. Microelectronics again has made it possible.

At Sperry Semiconductor, engineers are pressing further development of our metal oxide semiconductor technology for greater adaptation to integrated circuit functions. And at the Sperry Rand Research Center work is progressing on the next generation of integrated circuits. Development is underway on unique field effect transistors and on special insulating techniques that assure passivation of semiconductor surfaces.

Sperry's MK XIV is truly a low-cost computer. And this microcircuit computer is a digital reality, in production now. A new monopulse radar, the AN/FPQ-10 Instrumentation Radar—produced by our Radiation Division for the Pacific Missile Range—is the first such radar to use microcircuits.

For the military, NASA and industry—Sperry more and more is proving the true cost effectiveness of microelectronics, and through wide application is again showing the way.

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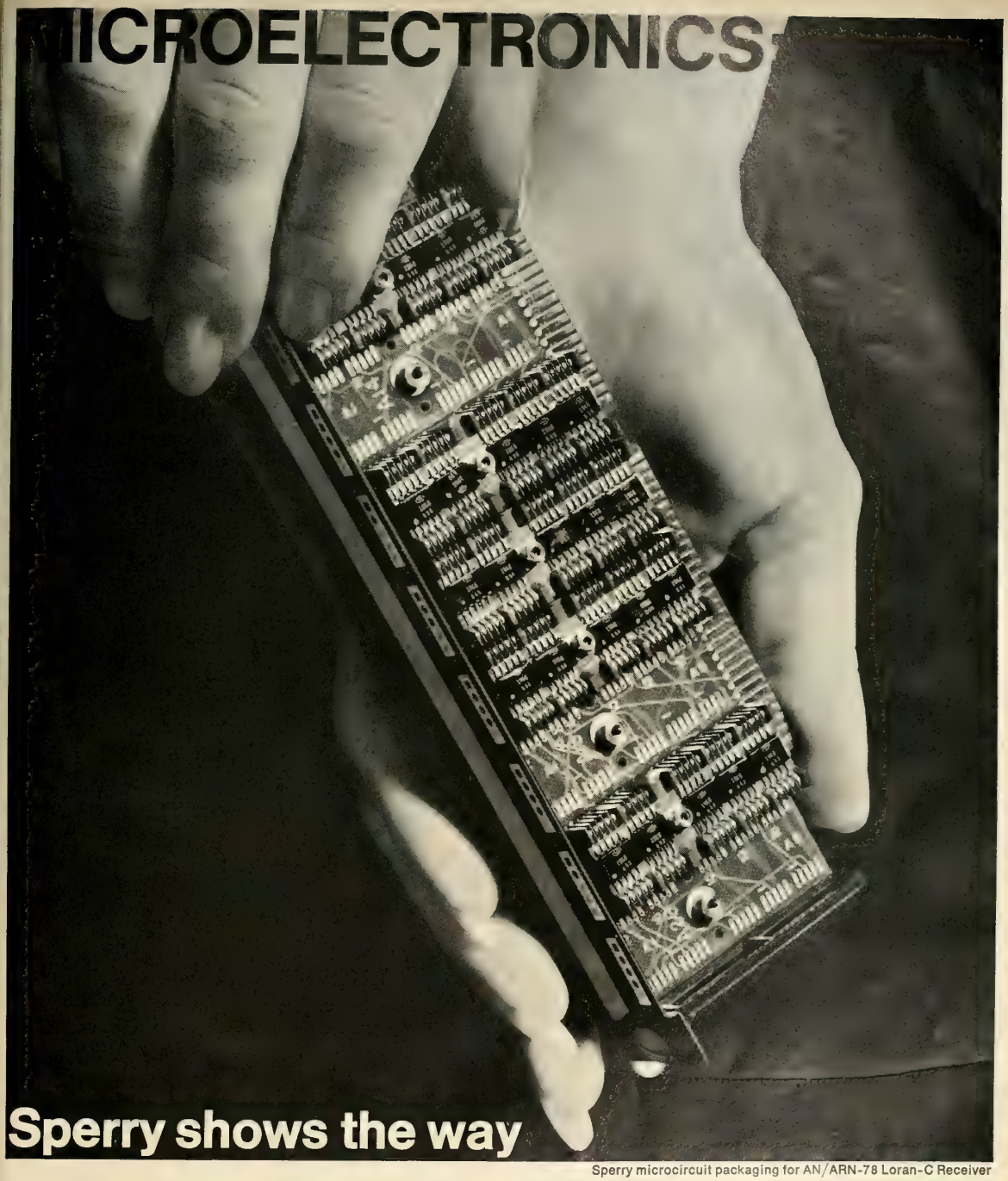

Sperry microcircuit packaging for AN/ARN-78 Loran-C Receiver

Just keeping up with a technology has never been Sperry's practice. Sperry is consistently out front in imaginative development and application of new technologies. Take microelectronics. More than 25 Sperry products and systems have highly reliable, designed-in microcircuits, among them these FIRSTS: microcircuit airborne Loran-C receiver; sonar system; in-production, low-cost digital computer; instrumentation radar; commercial inertial navigation system. And advances in related production methods, such as the Sperry-developed automatic hot gas circuit soldering technique, and improved integrated circuit packaging, add to the capability. Research, begun with semiconductor substrate functional blocks, is underway on the next generation of microcircuits. For more data, see column. *GENERAL OFFICES: Great Neck, N.Y.*

SPERRY

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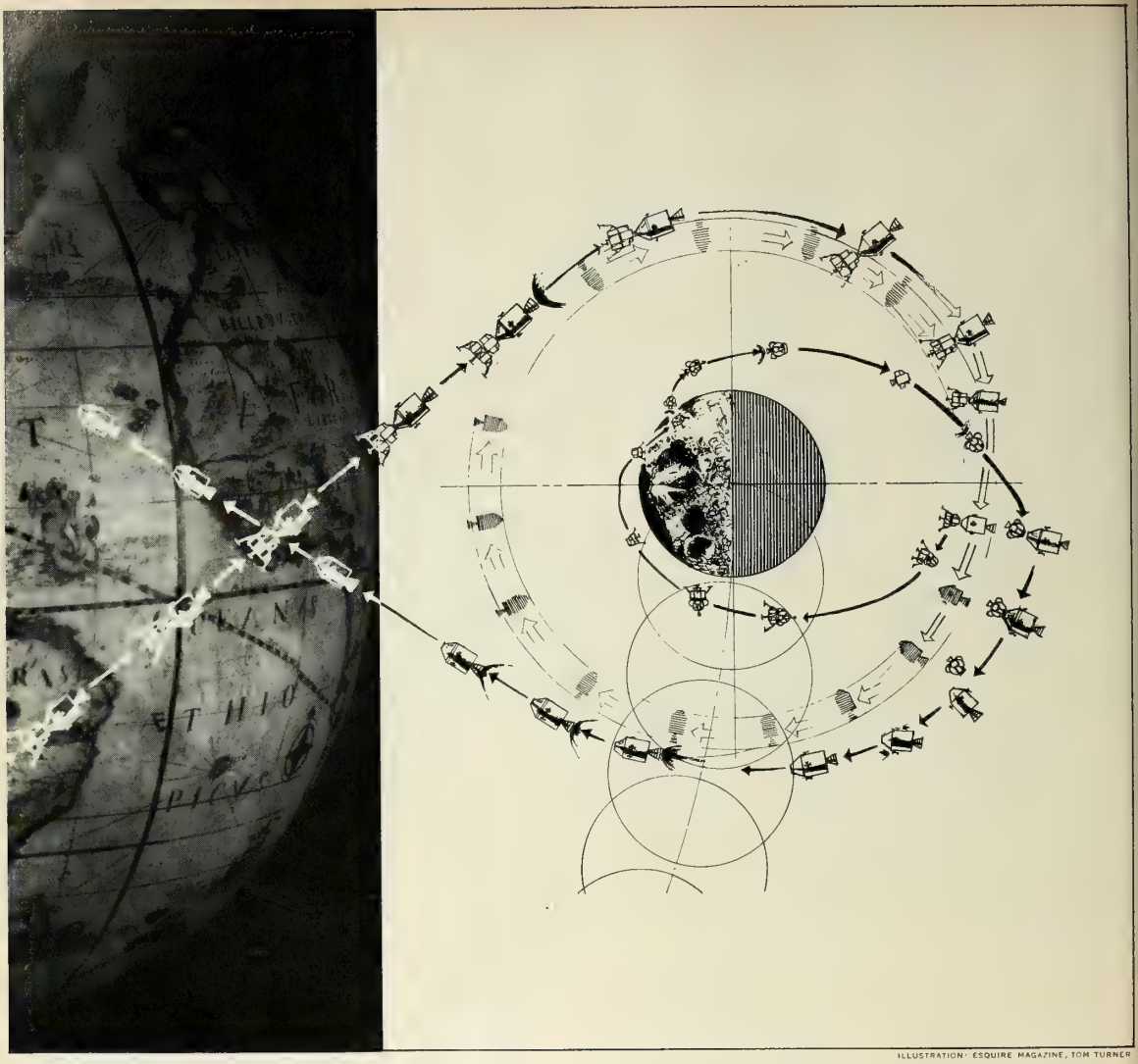


ILLUSTRATION: ESQUIRE MAGAZINE, TOM TURNER

When LEM men go down to the moon in ships...

TRW will help them get back. By 1970 two Apollonauts will descend onto the moon in their Lunar Excursion Module (LEM). A TRW propulsion system will land them feather-soft. They will explore the lunar surface, then prepare for the long journey home. After lunar blastoff they will rendezvous with their return vehicle, holding in orbit 80 miles out. During this lunar phase a TRW-built lightweight "strapdown" inertial guidance system will enhance their safety.

These major Apollo tasks have been assigned by Grumman to TRW Systems, the new name for TRW Space Technology Laboratories. TRW provides overall mission planning and analysis for NASA's Project Apollo, as it has done for the Mercury and Gemini programs.

TRW's participation in 90% of all U.S. space launches has created openings in: Inertial Guidance and Control; Mission, Trajectory and Guidance Analysis; Semiconductor Applications; Radar and Sonar; Communications and Telemetry; Experimental Mechanics; Dynamics and Structures Analysis; Aerophysics; Re-entry Systems; Spacecraft Heat Transfer; Space Propulsion; Microelectronics; Systems Research, Development and Analysis; Solid State Physics; and Applied Mathematics.

For TRW opportunities in Los Angeles, San Bernardino, Calif., Houston, Texas, Cape Kennedy, Fla., and Washington, D.C., write TRW Professional Placement, One Space Park, Redondo Beach, Calif., Dept. MR-8. TRW is an equal opportunity employer.

TRW SYSTEMS

Formerly TRW Space Technology Laboratories

The Countdown

WASHINGTON

MOL Decision Remains Elusive

It appears that the oft-delayed development authorization decision for the Air Force's *Manned Oribiting Laboratory* (*MOL*) has been pushed further into the future. Gen. Bernard A. Schriever, chief of the AF Systems Command, told the American Astronautical Society in San Francisco last week that the Pentagon's decision might be made "within a couple of weeks to a month." The "two more weeks" phrase has been regularly employed by DOD spokesmen since early July in predicting the "imminent" *MOL* decision.

Schriever Scores Lags in Comsats, Re-entry

In the same address, the AFSC boss took the opportunity to single out two areas in which, in his view, military development effort has lagged seriously. Noting that work toward a military communications satellite system began in 1957, he blasted failure to deploy it. "There is no question in my mind," he said, "that we should have in being a military comsat system now." He added that he believed that controllable re-entry vehicle technology has also been badly skimped in the military space effort.

Adams Succeeding Bisplinghoff

Dr. M. Carter (Mac) Adams, vice president and general manager for space systems, Avco Corp., will be named to succeed Dr. Raymond Bisplinghoff as head of NASA's Office of Advanced Research and Technology. Bisplinghoff, who originally resigned to become president of Case Institute of Technology, recently announced that he would not accept that position because of "compelling personal reasons." He will continue to serve the space agency as a special assistant to Administrator James E. Webb.

Wires Cross to Delay New OSO Shot

Launch date for the *Orbiting Solar Observatory* (*OSO-C*) has slipped from Aug. 24 to Aug. 25. Slippage was forced when a possible conflict arose in the use of NASA's Ft. Myers, Fla., tracking station. At the same time the station was to serve as command station for the *OSO* launch, it was learned, it would also be receiving data from *Explorer XXVI*. The agency then decided to delay *OSO-C*.

NASA Standing Pat on FY '66 Funding

Officials at this point are ruling out any request to Congress for a Fiscal Year 1966 supplemental appopriation request. They report that there is simply no need for additional funds at this time.

SRAM Development at Least a Year Away

Even the most optimistic estimates indicate that development of the Air Force's *Short-Range Attack Missile* (*SRAM*) won't begin before August, 1966. Requests for proposals from 12 industrial firms are due Aug. 30. Following receipt of the proposals and their evaluation, the Air Force hopes to "enter phase 1B" of project definition by mid-November. Phase 1B is expected to last four months, followed by Air Force and DOD evaluations consuming an additional four and a half months. Air Force spokesmen characterize *SRAM* as a "very tight program because it is something we need for our strategic posture."

Luczak Appointment Hints Stress on SAM-D

Army Materiel Command has named Col. B. R. Luczak project manager for its *SAM-D* surface-to-air defense missile system. Luczak, formerly manager of the cancelled *Mauler* project, is one of the Army's recognized experts on forward-area air defense on the battlefield. His appointment marks the first time in Materiel Command history that a system project manager's office has been established before the program has been authorized for development. Hence, the action is regarded as an indication that authorization of *SAM-D* development is virtually certain, and that the weapon is destined to receive the handling the Army reserves for high-priority, high-dollar projects. A prolonged round of briefings on the *SAM-D* concept throughout the Army and DOD is now complete. Development authorization is apparently being withheld pending a review of commonality characteristics in *SAM-D* and comparable Navy concepts.

INDUSTRY

Two Firms Due to be Chosen for OTS Study

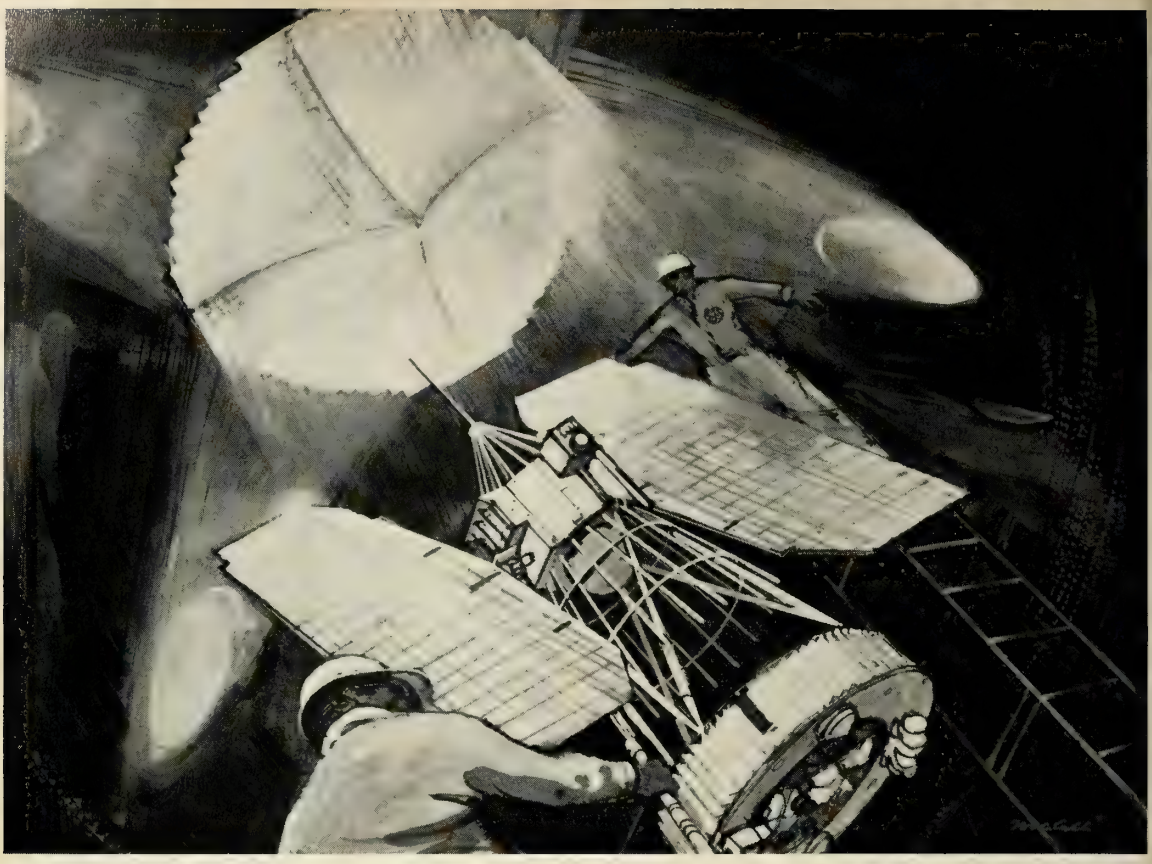
Announcement of the selection of two companies for the first-phase study of the *Optical Technology Satellite* is expected within the next couple of weeks. The source evaluation board's recommendation is now being considered at NASA headquarters. The first phase calls for conceptual design of the satellite, which could become part of the *Apollo Extension System* (*AES*) experimental program.

Raytheon Investigating Self-Propelled Hawk

Raytheon Co., Lexington, Mass., has been awarded a $1.6-million Army contract for development of a self-propelled *Hawk* missile system for use in forward combat zones. The missile will be mounted on an XM-548 tracked vehicle to provide mobility and flexibility. Currently transportable, but scarcely mobile, *Hawk* in this configuration would be carried ready-to-fire in an effort to fill the field-performance need for which the cancelled *Mauler* was being developed.

Legislators Slate Visits to Plants

A delegation of House Space Committee members headed by Chairman George P. Miller (D-Calif.), Space Sciences subcommittee chairman Joseph Karth (D-Minn.) and NASA Oversight Subcommittee chairman Olin Teague (D-Tex.) will visit Jet Propulsion Laboratory in about two weeks to inquire into the status of the *Surveyor* program. They will also interview project personnel at Hughes Aircraft. Post-adjournment plans for committee members include trips to major space contractors, as well as all NASA installations. Among those on the itinerary are North American, Douglas, Lockheed, Martin, Aerojet and Boeing.



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Real satellites face their first moments of truth in our make-believe world where outer space is realistically simulated, including a true collimated "sun source" and wall temperatures cryogenically controlled as low as minus 300 degrees.

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Here, at the free world's largest and most comprehensive privately owned space research facilities, you'll find yourself engaged in such challenging programs as Orbiting Astronomical Observatory, Bio-satellite, Mark 12 Re-entry System for Minuteman II, Maneuverable Ballistic Re-entry System, Nimbus Weather Satellite, and Gravity Gradient Stabilization System (MAGS).

Immediate openings now exist at Valley Forge and Philadelphia, Pa. in **systems analysis...systems simulation...guidance & control analysis...measurements & environments...materials development...structural mechanics...project engineering...guidance & control equipment design...command & telemetry design...radar discrimination...nuclear power** (SNAP)**...electro-chemistry...and nuclear effects.**

Interested applicants are invited to inquire further by writing to Mr. J. S. Barson, Dept. 394H-4, Space Technology Center, General Electric Co., P.O. Box 8555, Philadelphia 1, Pa. An equal opportunity employer.

MISSILE & SPACE DIVISION

GENERAL ELECTRIC

Minuteman Warhead Refined

North American Aviation's Autonetics Div. announced Aug. 18 that it has received an Air Force Ballistic Systems Div. contract to develop a maneuverable re-entry vehicle for the *Minuteman II* ICBM.

The so-called post-boost control system will employ small liquid motors to be built by Textron, Inc.'s Bell Aerosystems Co. Div. to provide attitude and velocity control for the vehicle. The system, in combination with the *Minuteman's* inertial guidance system, would constitute a complete closed-loop velocity and attitude-control system for use after cutoff of the missile's third-stage.

Airmen Pull TDY at MSC

NASA and the Air Force have signed an agreement under which 128 Air Force officers will be detailed to the Manned Spacecraft Center for 2 years.

Their assignments in flight operations at the center will augment NASA flight operation organizations while providing the officers with on-the-job training and experience in the operational control of manned space flights.

The first group of officers arrived for duty at the center earlier this month.

Sprint Fuel Study Awarded

The *Nike-X* Project Office, Redstone Arsenal, Huntsville, Ala., has awarded the Aerojet-General Corp. a $499,403 contract to explore possible use of a rubber-base, composite propellant for the *Sprint* anti-missile missile.

The contract calls for a nine-month development program, including manufacture and test firing of two *Sprint* first-stage motors. The propellant Aerojet will be demonstrating is a polybutadiene composite.

Comsat Enters Apollo Picture

The Communications Satellite Corp. announced last week its receipt of one proposal for construction of synchronous satellites from Hughes Aircraft Co. and five proposals for transportable Earth stations for providing communications services for space exploration, particularly in the *Apollo* program.

Companies responding with Earth station proposals included Hughes Aircraft Co., International Tele-

North Vietnamese Surface-to-Air Missile Site

AERIAL RECONNAISSANCE photo of North Vietnamese missile site released last week by Dept. of Defense. Larger arrows point to four SAM missiles on racks. Inset at upper left is enlargement of missile boxed at lower right. Arrows at right center indicate trucks with radar guidance equipment. DOD has identified seven such sites in North Viet-Nam. The Department has refused to confirm or deny a British newspaper report that the U.S. has information to the effect that there are at least 20 SAM sites under construction in the vicinity of Hanoi, on the grounds that such a disclosure would not be in its best interests.

SIDE-LOOKING RADAR SYSTEMS ANALYSTS

New programs at HUGHES are generating opportunities for Systems Analysts experienced in high-resolution data gathering, data transfer and data processing systems. Openings exist for Systems Engineers, Mathematicians and Physicists qualified in synthetic array radars, optical, and other data collection systems (IR, Electro-Optical, SIGINT and others). Assignments include:

Senior Systems Scientist with 20 years' electronic systems experience —at least 10 years relevant to side-looking radar systems. Applicants will be considered for important program management responsibilities. M. S. or Ph. D. degree required.

Senior Systems Analysts with 10 years' electronic systems experience —at least 5 years relevant to high-resolution systems pre-design and evaluation. Applicants will be considered for assignments in concept formulation; single and multi-sensor applications; data transmission, processing and interpretation; systems integration and performance evaluation. M. S. or Ph. D. required.

Systems Analysts with 5 years' experience in: detection of signals in noise, optimum filter theory, nonlinear signal processing, information theory, MTI and doppler systems analysis. B. S. or M. S. required.

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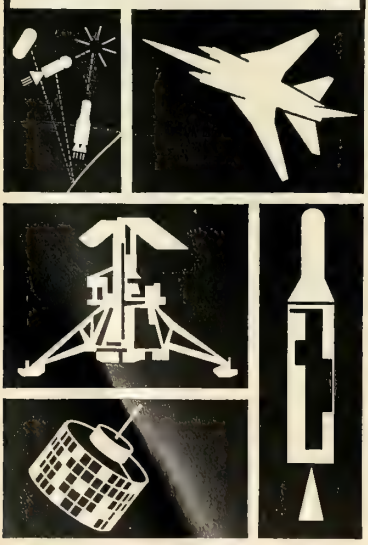


phone and Telegraph Corp., Page Communications Engineers, Radio Corp. of America, and Sylvania Electronic Products, Inc.

Comsat requested the proposals in response to an invitation by the National Communications System (NCS) for cost estimates and other details related to the communications service, and gave Aug. 23 as the date it would reply to the request.

RFP's solicited by Comsat involved four synchronous spacecraft, with options for additional vehicles, first delivery to be accomplished within 8 months.

ERC Design Approved

CAMBRIDGE, MASS.—NASA has authorized the Electronic Research Center here to proceed with detailed architectural design of its first three buildings.

The buildings include a 26-story, 378-ft. tower and two three-story buildings. The tower will house portions of the center's Qualifications and Standards Lab, the Electronic Components Lab and engineering and administration functions. The two three-story buildings will house special-purpose equipment for the Microwave Research Lab and an auditorium-cafeteria.

Construction is expected to start in the spring of 1966, with occupancy two years later. Any potential problems remaining for the Center in its quest for local approval under urban renewal procedures are expected to be ironed out at an Aug. 30 public hearing of the Cambridge Redevelopment Authority. Plans for the 13-acre industrial park adjacent to the site will also be aired at the meeting.

Astronaut-Scientist Resigns

Dr. Duane E. Graveline, a NASA medical doctor and one of the space agency's six new scientist-astronaut trainees, resigned from the astronaut program Aug. 18 for "personal reasons."

Graveline will return to his former job in NASA's medical observations office at the Manned Spacecraft Center in Houston.

Shots of the Week

The Air Force on Aug. 18 successfully launched the first *Minuteman II* ICBM in a planned series of eight shots to prove the operational readiness of the weapon. The missile, launched from Vandenberg AFB, Calif., impacted 5,000 mi. downrange in the intended target area. A second firing of the system is expected within a few weeks.

• The Army's surface-to-surface *Lance* missile successfully underwent its sixth flight test from White Sands Missile Range, N.M., Aug. 18.

Proton I Described

The Soviet news agency Novosti last week released a newspaper story describing the instrumentation of the 26,800-lb. *Proton I* space station launched July 16.

Placed in a 370/112-mi. Earth orbit by a powerful new booster, it carries instruments for the study of solar cosmic rays and the radiation hazards inherent in them; the study of the energy spectrum and the chemical composition of the primary cosmic ray particles in the energy interval up to 10^{14} electron volts; the study of the nuclear interactions of extremely high-energy space particles of up to 10^{12} electron volts; the determination of absolute intensity and energy spectrum of electrons of galactic origin; the determination of the intensity and energy spectrum of the galactic gamma rays with energies exceeding 50 million electron volts.

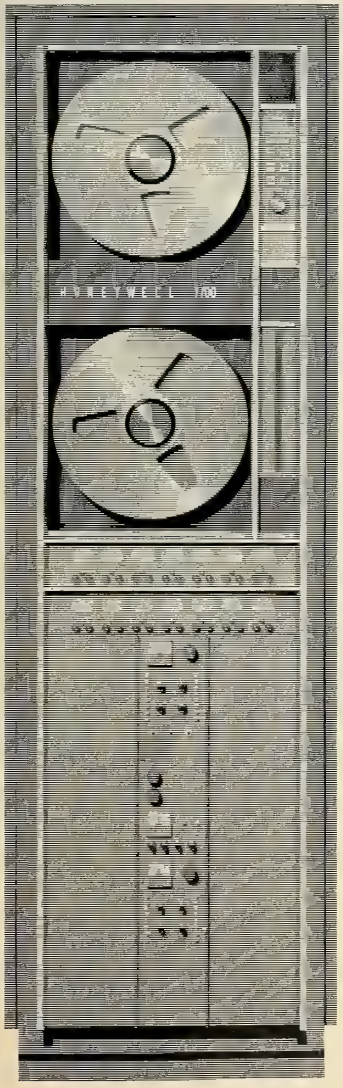
To accomplish the necessary measurements for such studies, the station carries a complex of instruments, including an ionization calorimeter with associated instruments for measuring energy, for determining the nature of particles of cosmic rays, and for studying their interaction with matter; a device for studying high-energy electrons; a gamma ray telescope for registering gamma-quanta of high energy; an instrument for studying the chemical composition and energy spectrum of cosmic rays of moderate energies.

• **Special instrumentation**—To enable selection of only those particles of the highest energies for study, Soviet physicists devised an ionization calorimeter consisting of a large number of steel plates separated by phosphorescing plastics. When a high-energy particle strikes the calorimeter, the particle interacts with the atomic nuclei of Fe atoms. The collision results in secondary particles being produced. These then collide with Fe nuclei, producing particles of the next generation. The process continues in like fashion until the entire energy of the primary particle is transferred to a large number of secondary particles, which are absorbed in the calorimeter.

The absorption of the energy results in light flashes in the plastics of intensity proportional to the energy of the particle. The light flashes are registered by photomultipliers and telemetered to Earth. The same

The Honeywell 7700 introduces these four significant advances in analog magnetic tape instrumentation:

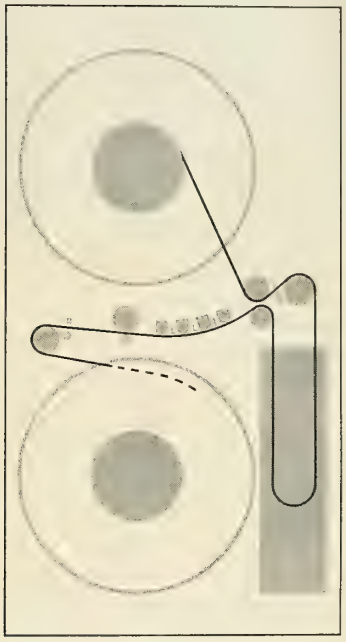
TIME DISPLACEMENT ERROR—Timing errors between record and playback can originate in dimensional changes in the tape caused by temperature, humidity and tension variations as well as differences in tape speed between record and playback. These effects have been minimized through use of a tape-controlled servo on the playback mode. Until now, however, high inertia systems could only reduce instantaneous timing errors to about 1 millisecond. The new Honeywell 7700 low inertia, high-response servo reduces this error to 1 *microsecond* at 120 inches per second.



FLUTTER—In the past, flutter has been reduced by use of high inertia drive systems which lose their effectiveness at low frequencies and low speeds. The high-response servo in the Honeywell 7700 virtually eliminates flutter below 100 cps and holds wideband flutter below 0.25% from DC to 10KC at 60 ips.

DYNAMIC SKEW—If data on two or more channels are to be compared, it is essential that varying time differences between channels caused by dynamic skewing of the tape be reduced. The use of vacuum column isolation and a 13-inch edge guide ahead of the record-playback heads reduces dynamic skew in the Honeywell 7700 to approximately one-third of that in state-of-the art analog systems.

SIGNAL/NOISE RATIO—Noise caused by electronics, tape and the tape transport can mask small amplitude data changes. Efforts to improve linearity, drift and other parameters are fruitless if a high percentage of noise is present. The Honeywell 7700 will produce signal-to-noise ratios as great as 48 to 52 db rms. This is a 2-to-1 improvement over the 40 to 44 db noise found in other FM systems.



The Honeywell 7700 is an 80 KC FM-640 KC Direct system built specifically to preserve the quality of your most critical data.

For complete specifications, call a scientific field representative at your nearest Honeywell office, or write Mail Station 402, Honeywell, Denver Div., Denver, Colo. 80217. In Canada: Toronto 17, Ontario.

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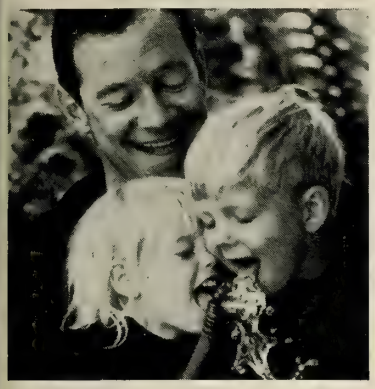


Other openings in Mechanical Engineering

Douglas Aircraft Group's expanding programs on the DC-8, DC-8F, DC-9, A-4E, and the new series 60 DC-8 family have created excellent openings at several levels of experience.

Hydro/Mechanical

Hydraulic Component Designers; Landing Gear Specialists; Hydraulic System Engineers; System Dynamic Analysts; System Installation Designers.

Mechanical Controls

Mechanical Designers *of controlling Components;* Electromechanical *Actuator Specialists;* Control Systems *Engineers;* Layout Engineers *for Cable and Bracket Locations;* Aeronautical Engineers *for Design of Aircraft Controlling Surfaces.*

Automatic Controls

Dynamic Analysts of Control Systems; Electrical Designers of Autopilot Components.

Support Equipment

Electronic Packaging Engineers *for flight simulator Design and Test Equipment;* Mechanical Design Engineers *of Aircraft Handling Equipment;* Mechanical Engineers *with Experience in Commercial Cargo Handling Equipment.*

Model Design

ME *or* AE Engineers *experienced in wind tunnel testing design of models for testing, would be working in small groups.*

Armament

Mechanical Designers *of Bomb Racks and Electromechanical Release Mechanisms. Also performs analysis and design of weapon control systems.*

principles are used in another apparatus in *Proton I* to measure the energy of electrons in particles.

Two special counters are placed over the calorimeter to study the nature of cosmic ray particles by measuring their electrical charge. The employment of two independent counters is intended to substantially improve measurement of the charges and to make possible separation of the primary high-energy protons from heavier particles.

Located beneath one counter are a carbon bar and a polyethylene bar (composed of atoms of hydrogen and carbon). Under the bars are the interaction detectors. The interaction of ultra-high-energy particles with the nuclei of carbon atoms can be studied in one half of the apparatus and that with carbon and hydrogen in the other half.

A scintillation counter located under the ionization calorimeter is employed in conjunction with the interaction counter to separate particles that move in a definite direction.

A specially designed gamma ray telescope registers gamma-quanta of the primary cosmic radiation, determines the gamma-quanta energy spectrum at energy levels of 10^8 to 10^9 electron volts, and measures the energy spectrum and chemical composition of the primary cosmic rays of galactic origin subject to the influence of the geo-magnetic field. It also studies the energy spectrum and chemical composition of the cosmic rays of solar origin.

Novosti reports that the equipment onboard *Proton I* was functioning normally three weeks after launch and that it was beginning to "fulfill the set program."

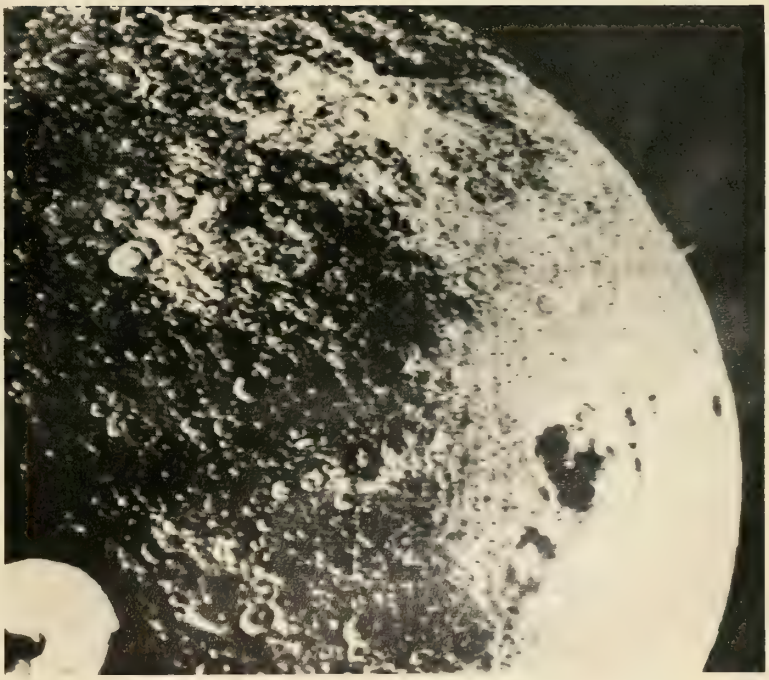
MSC Support Pact Let

Lockheed Electronics Co., Clark, N.J., has been selected to provide operational support services for laboratories and test facilities at the NASA Manned Spacecraft Center.

The contract will provide for support services at the Instrumentation and Electronic Laboratories, Information Systems Laboratories, Guidance and Control Laboratories and Space Environmental Laboratories.

NASA solicited 128 firms Dec. 3, 1964. Of these, 48 attended a preproposal conference Dec. 16, 1964.

Ling-Temco-Vought, Inc., Dallas, and Lockheed were selected last April for final competitive negotiations.



Russian Photograph of Moon's Far Side

EQUITORIAL and northern parts of the Moon's far side are shown in just-released picture transmitted by Soviet Zond 3 lunar probe on July 20. According to the Tass news agency, the photo was taken 7,200 miles from the Moon's surface. Craters of less than 3 miles in diameter are said to be discernible.

Report Blasts Aerospace 'Violations'

House subcommittee report charges failure to observe official contract policy caused waste of millions; Air Force also criticized

AEROSPACE CORP. has "continually violated Government policy in its contract dealings with the Air Force, with resultant needless expenditures of millions of dollars of public funds," a Congressional subcommittee has charged.

In a report that scores both the nonprofit company and the Air Force for mismanagement in a multitude of areas, the House Armed Services Special Investigations Subcommittee calls for a reappraisal of the Air Force management concept that led to formation of the corporation, with a view toward determining the need for using outside organizations to help carry out the basic planning and subsequent management of military missile/space programs.

The report follows lengthy hearings by the subcommittee, chaired by Rep. Porter Hardy (D-Va.), and months of investigation by General Accounting Office auditors and the subcommittee staff. The probe was precipitated during a review of Dept. of Defense welfare and recreation expenses, when the subcommittee found "slipshod control of certain expenditures at Aerospace . . ." and "an attitude . . . that, although it is a wholly Government-supported, nonprofit corporation created by a Government agency, the Congress' auditing agent, the General Accounting Office, did not have a right to review all of its expenditures."

The whole question of the role of nonprofit organizations in the conduct of the Government's business was called into question by the subcommittee, which pointed to the proliferation of these groups and the lack of a consistent national policy governing their role. It cited the possible effect on morale in the Government's effort to improve the quality of its own career service, noting a "ludicrous" cycle of competition between agencies and nonprofits for salary increases.

Future attention must be directed, the report said, to the questions of whether the management concept is viable on a permanent basis, and whether the Air Force's concept is still needed, considering the changes in the situation since 1954. It cited the success of the Navy with its in-house management of programs such as the *Polaris* and its nuclear submarine.

Another area requiring study, the subcommittee said, is the relationship between Aerospace and private industry organizations which perform almost solely research and development work.

● **Other findings**—The subcommittee also charged that the corporation rejected the Air Force policy for nonprofit corporations which says that any fee should be determined on the basis of need, demanding that they be paid on "worth of task." "As a result, fees were provided for purposes for which they were never used and Aerospace used fees for purposes never intended by the Air Force." This arrangement led to a loss of adequate control over reimbursable expenditures, as contracting and auditing personnel were aware that expenses disallowed as reimbursable were frequently financed out of fee, the group reported.

The report also attacked Aerospace's failure to use the fees—which it pointed out were higher than commercial firms received because they were tax-free—in the pursuit of independent research for which they were intended.

The Air Force was charged with negligence in failing to exercise proper control and guidance over the corporation. The subcommittee said that the one Air Force contract officer who "attempted to bring order out of chaos" was subsequently removed. This "calls into the question the ability of the Air Force to cope with the management of problems attending its organization of space programs, and will require continued Congressional surveillance," the committee charged.

● **Recommendations**—The Congressional group exhorted the Secretary of the Air Force to take such steps as required to insure the prudent control of public funds expended through Aerospace. At the minimum, it said, this should include full enforcement of Air Force standing policy, and a review to see what other safeguards are needed.

It called for title to facilities and real property of the corporation to go to the Government, an action which it recommended as standard policy for nonprofit firms. It charged that the company purchased land and constructed facilities on a number of occasions, although either or both were not required. The effect, it said, was that the Air Force got handsome facilities for its Space Systems Division without obtaining the normal Congressional authorization and appropriation.

The subcommittee also called for abolishment of the fee system, in favor of a combination of reimbursement and an advance payment pool to cover independent research, operating capital and contingencies. Failing this conversion, it said, Aerospace should be required to make detailed, regular disclosure to the Air Force concerning the use of its fee expenditures.

The committee related testimony of an Air Force contract officer who alleged that he asked 200 times for a statement on the use of the fees and was refused. When his appeal to a higher Air Force authority for guidance was ignored, he said, he was forced to assume that this followed Air Force policy. Internal memoranda recommending methods of circumventing the Air Force's control also were quoted.

● **Security problem**—The report strongly criticized the handling of personnel problems with security implications both by Aerospace and the SSD security office. While no actual security violations were disclosed, it was charged that Aerospace for several years either ignored or was unaware that a $15,000-a-year technical staff member with a secret clearance had a record of several morals convictions. Other, lesser, examples were cited.

While some changes since the subcommittee's hearings were noted, including submission of detailed information on fees, the Congressional group noted some reservations, especially in the light of the dismissal of the Air Force contracting officer. Among the points which it said warranted further rectification were the high public relations fees, the maintenance of a separate office in Detroit for the chairman of the board, security procedures, and salary and personnel policies.

"Many of the ills of Aerospace might never have occurred if Aerospace officials and the Air Force retained an awareness that their public trust extended to uses of all funds, as well as to missile technology, and that the funds that they were spending were in truth public funds," the committee concluded. ■

U.S. Bids to Seize Space Leadership

Eight-day flight would add manned-spaceflight edge to previously demonstrated superiority in unmanned lunar and planetary exploration

HOUSTON—The U.S. this week is expected to take over world space leadership with the flight of the *Gemini 5* spacecraft.

The *Gemini/Titan II* lift-off was scheduled for Aug. 21, following a two-day delay on Aug. 19 caused when a lightning bolt caused a power surge on the *Gemini* spacecraft.

Even as NASA officials set the new launch date, they indicated that further slippage might occur because of a fire that destroyed a communications cable on Cape Kennedy. Other problems demanding solution included locating the cause of the drop in telemetry power in the spacecraft backup system and verifying that the computer memory had not been wiped out by a surge of electricity caused by lightning in the Cape area.

If the mission's goal of eight days in orbit is fulfilled, it will give this country the unquestioned lead in manned spaceflight. The 121-revolution flight is scheduled to last 191½ hrs., surpassing the previous 119-hr., 6-min. flight of Russia's Valery Bykovsky on June 14-19, 1963, as well as giving this country a comfortable margin in total man-hours in space.

The *Ranger* space flight series has already given the U.S. the lead in unmanned exploration of the Moon. The *Mariner II* and *Mariner IV* flights to Venus and Mars, respectively, clearly give NASA the trophy for exploration of the planets.

● **Legion of troubles**—A power surge on the *Gemini* launch complex that may have damaged the computer memory on board the spacecraft called a "scrub" to plans to launch on Aug. 19.

Thunderstorms in the immediate area only minutes earlier had prompted mission planners to raise the erector around the *Gemini-Titan* combination. The pre-launch count was halted at T minus 10 min. to search out an indication of a problem in the spacecraft's telemetry system.

Problems began plaguing the launch team late Aug. 18 when liquid hydrogen kept at −424°F in the fuel-cell cryogenic storage system began to "boil off" at an unexpected rapid rate. A hold in the count was called at T minus 300 minutes while engineers topped off the hydrogen supply to assure a 100% supply at lift-off. Hydrogen is mixed with oxygen in the fuel cell to produce spacecraft electrical power from launch to just before retro fire.

An additional 4% of liquid hydrogen was forced into the container under pressure after three hours and eighteen minutes, delaying lift-off to 12:18 p.m. EST. The short period of daylight remaining in the primary Atlantic recovery area and two typhoons skirting about the secondary Pacific recovery zone added to mounting problems.

The long-duration mission, with its associated medical observations, will study the effects of prolonged weightlessness on man. It has been purposely extended to eight days to duplicate the time period of a typical lunar mission.

● **First rendezvous**—A secondary objective is to rendezvous with an orbiting object—a rendezvous evaluation pod—(REP)—which will have been ejected from the spacecraft adapter several orbits earlier. Command Pilot L. Gordon Cooper, Jr., will maneuver the spacecraft into a rendezvous trajectory that duplicates in one-third scale the rendezvous and docking approach with the *Agena* target vehicle during *Gemini 6* later this year.

The pod will respond with range rate and bearing angle to signal from the spacecraft rendezvous radar. The onboard spacecraft computer will process the incoming data, compare it to a stored program, and display thrust adjustment (Delta) and direction necessary to place the spacecraft on a collision course with the REP. Rendezvous is planned 5 hours and 36 minutes after lift-off, over Carnarvon, Australia.

Experiments and operational checks during *Gemini 5* will be "written" into the flight plan according to priority of real-time events during the eight days in space.

Although flight controllers will follow a general flight plan outline, actual scheduling of events following the rendezvous exercise will be made from one orbit to the next.

Up to 250 lbs. of propellant—out of 400 lbs. onboard capacity—have been budgeted for the first five orbits which include orbital adjustments, the

ASTRONAUTS L. Gordon Cooper, Jr., (left) and Charles Conrad check out Gemini 5 spacecraft atop Titan II booster at Cape Kennedy prior to launch.

rendezvous exercise, and the nearby object photography experiment. Approximately 80 lbs. are reserved for remaining experiments.

● **Nearby object photography (D-2)**—After the rendezvous, the spacecraft will move to within 40 ft. of the REP to begin in-plane photo-reconnaissance of the orbiting object. Cooper will affix a reticle in his window. Pilot Charles Conrad will use a 35-mm Zeiss contarex camera with black and white film and two lenses for the experiment (Nikkor F/4 with 200-mm focal length, and questar with 1,270-mm focal length). A 16-mm motion picture camera will be affixed and operating in the right window. The experiment will begin as sunlight illuminates the REP.

● **Celestial, space and terrestrial object radiometry (D-4 and D-7)**—A *Thor-Delta* carrying the *Orbiting Solar Observatory* may be included in the missile readings of these measurements, which are to collect basic scientific data of natural and man-made objects in the ultraviolet-visible-infrared ranges. Pod measurements will be made early in the mission with a time-critical infrared sensor cooled to cryogenic temperatures.

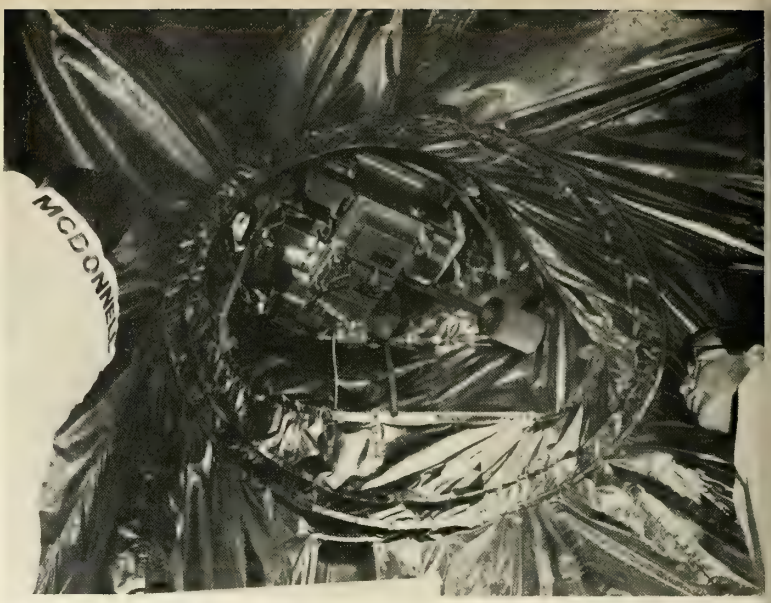
● **Medical**—Two new medical experiments on *Gemini 5* are cardiovascular conditioning and human otolith function:

—*Cardiovascular conditioning (M-1)*—This experiment attempts to develop countermeasures to cardiovascular deconditioning in zero-gravity brought about by the uneven distribution of blood in the body, or "pooling." Pneumatic cuffs around Conrad's upper thighs will be automatically inflated to 80 mm of mercury for two out of every six minutes continuously through the mission.

—*Human otolith function (M-9)*—This experiment attempts to measure changes in gravity sensors of the inner ear (otolith) brought about through prolonged weightlessness. Each man will look through special binoculars at a light source in the form of a movable white line, and attempt to align the light horizontally to what he believes to be the pitch of the spacecraft. The number value on the calibrated knob will be compared to measurements made before and after the mission for an indication of change due to zero-gravity. The equipment is incorporated into the in-flight vision tester used for the visual acuity experiment.

● **Deposit studied**—The *Gemini 5* flight is also expected to provide additional information on the cause and composition of a mysterious deposit which has formed on the spacecraft's window during re-entry of previous *Gemini's* into the Earth's atmosphere.

NASA currently has a theory as to the cause, based on preliminary findings, and hopes that instrument readings taken by the *Gemini 5* crew will confirm it.



RENDEZVOUS EVALUATION POD (REP) shown installed in Gemini 5 spacecraft. Designed to test radar and guidance system developed for rendezvous and docking with an orbiting Agena rocket, REP is ejected from adapter section.

Astronaut James McDivitt first brought the deposit to public attention when he told the space-walking Astronaut Edward White that he was smearing up his windshield.

NASA thermal structure analysts at the Manned Spacecraft Center now believe White's glove disturbed a film of "clear silicon oil" deposited on the windshield by material ablating during lift-off.

They theorize that the smeared film was "cooked" during re-entry, then redeposited on the spacecraft and windows in a layer 0.001 in. thick and resembling ground glass.

David Greenshields, chief of the thermal structures branch, said the oily launch deposit was reproduced in ground tests after having traced its possible source to a non-metallic nose fairing which covers the spacecraft rendezvous radar during boosted flight. The fairing, one of several non-metallic, ablative materials on the surface of the spacecraft, is the only one reaching high temperatures (110°F) during launch. It is made of the same materials as the spacecraft heat shield, Greenshields said.

It was first thought that the material was smeared onto the window from White's glove, he said. An analysis of the glove, however, produced no trace of silicon oil deposit.

"We are considering replacing the nose fairing with a non-ablative, radiative type of material that will not degrade during launch," Greenshields said. The horizon scanner cover, the parachute harness stowage slot cover (from nose to heat shield between the windows), and silicon gaskets around the windows may also be replaced with a non-ablative material.

The re-entry silica deposit was first observed by *Gemini 3* astronauts during the re-entry portion of their mission, he said. The window "flashed" as light hitting it at an angle became scattered by the deposit. Engineers found the same silicous deposit on the *Gemini 3* windows.

The *Gemini 5* crew will make photometric readings of the windows immediately after launch and just before re-entry to determine the distribution of the oily launch deposit and the extent of light attenuation through the windows. A comparison of readings will also show accumulation occurring during the orbital phase of the flight.

The photometer, which is part of the visual acuity experiment equipment, is located on the right window sill in a 16-mm camera mount. It looks into a light trap—a black cavity affixed to the spacecraft afterbody shingles outside the window. If the window is perfectly clear, the light meter will read "zero."

Cooper will roll the spacecraft into an attitude that aligns sunlight to the plane of the right window at a 50-degree angle of incidence. The black sky will be in the background. Conrad will remove the photometer from its mount and will scan the window. The readings will be telemetered in real time. ■

Senate Committee Bolsters MOL

Action to prevent reprogramming comes in reporting DOD's $46.7-billion appropriations bill; SRAM fund cut sustained

THE SENATE Appropriations Committee has performed the final action to save the *Manned Orbiting Laboratory* (*MOL*) from any reprogramming within the Dept. of Defense, ensuring by language in the bill that the $150-million fund cannot be used for any other purpose.

The committee has reported out a bill recommending appropriations for DOD totaling $46,756,319,000. Together with some $3 billion available to DOD from other sources, FY 1966 programs recommended total $49.8 billion. This includes the full $1.7-billion emergency fund for Southeast Asia requested by Secretary of Defense Robert S. McNamara. Allowing for the fact that the House bill did not include the emergency request, the Senate bill is actually $11.1 million lower. It is $95.7 million less than the budget estimate.

Sen. John Stennis (D-Miss.), acting chairman of the Defense Appropriations subcommittee, issued a statement pointing out that he would have preferred that the full bill for all of the costs incurred in Viet Nam be presented to the Congress at this time. He noted that the committee was unsuccessful in obtaining an estimate of the additional funds which will be required for these purposes. His own estimate, he said, is that at least $7-10 billion in additional funds will be required annually to support combat operations in Viet Nam and to replace equipment diverted there.

● **RDT&E**—The Senate committee concurred with the House in the cuts made in the research, development, test and evaluation category, which means that these items will not be brought up in conference, the action being, in effect, finalized if passed by the Senate.

This includes a total of $3,103,900,000 for the Air Force, with cuts totaling $10.2 million in military sciences, $30.7 million in the *Short-Range Attack Missile* (*SRAM*), and $10 million in the XB-70 flight program.

The committee also went along with the addition of $22 million for the Advanced Strategic Manned Aircraft, and added language that the fund could only be used for that purpose, in the same manner as the $150 million for *MOL*.

Army RDT&E was recommended at $1,406,400,000. This includes reductions of $17 million in military sciences, $2 million from Federal contract research centers, $6 million from "other equipment," and $6 million for R&D from a classified installation not authorized by the Congress.

RDT&E figures of $1,439,200,000 reflected cuts of $19.7 million in military sciences and $3.7 million in "integrated light attack avionics." While the House specifically disallowed the request of $10 million for the *Advanced Surface-to-air Missile*, the committee said that it felt that this program should be continued, but at a level substantially lower than that proposed in the budget estimate. Therefore, it recommended that $4.6 million be made available for this program.

Defense agencies RDT&E funding was recommended at $495 million, reflecting a cut of $500,000 from the Advanced Research Projects Agency "behavioral sciences" category, and the balance of $4.9 million reductions to be applied by the Department.

The Senate committee cut the $150-million R&D emergency fund by $50 million, although the House had allowed the full amount. In taking this action, the committee said that it was particularly concerned over the utilization of this appropriation for other than emergency purposes.

● **Procurement**—Total procurement programs recommended were $13,939,562,000, including appropriations of $11.3 billion and $2.5 billion available from sources other than new obligational authority.

Air Force missile procurement was recommended at the same amount as the House, a total of $796.1 million, with $365 million anticipated to be available from other sources. This includes approximately $422.6 million for *Titan II* and *Minuteman II;* $34.5 million for other missiles and drones used by the tactical and air defense forces, including *Bullpup, Shrike,* and *Firebee.* Another $266.4 million is programed for modification of in-service missiles, with the remainder for spares and other support.

Total Air Force aircraft procurement was recommended at $3.5 billion, with $300 million expected to be available from other sources. Other Air Force procurement was recommended at $829.1 million, with an additional $95 million expected to be available.

Army missiles and equipment procurement was set by the committee at $1,204,800,000, with an additional fund of $812.8 million expected to be available. The total reflects concurrence with the House reduction of $10.1 million based upon program changes by the Department, and $7.2 million in the funds requested for the procurement of electronics equipment. However, the Senate also voted to disallow a $1-million request for an electronic-communications system planned for a classified facility that has not been authorized.

Navy aircraft and missiles were recommended at $2,272,500,000, with another $277,462,000 anticipated to be available. The committee concurred with a cut in the F-4 aircraft program, and a $4.2-million reduction in the F-111B program.

The Navy shipbuilding procurement fund was set at $1,590,500,000, a net increase of $89.4 million reflecting additions made by Congress for additional attack submarines and long-leadtime procurement for a nuclear-powered guided missile frigate against reductions for two fast deployment logistics ships. Other Navy procurement was recommended at $1,149,900,000, with an additional $17.7 million expected. ■

Air Force Curtailing Two Offices at Hanscom Field

The Air Force Electronic Systems Div., Hanscom Field, Mass., has reported the phase-down of its Air Weapons Control System (412L) program office and the phase-out of the Nuclear Detonation Detection and Reporting System (477L) project office.

Former 412L personnel have been assigned to the newly established Ryukyu Air Defense System (RADS) program office and a new Hawaiian Air Defense System has also been assigned to the office. In discontinuing the 477L program office, Air Force spokesmen said remaining contract responsibilities have been transferred to the Contract Methods Div. of the ESD staff procurement and production office.

only a beginning . . .

MISSILES AND ROCKETS will publish its Fifth Annual NASA Issue November 29, 1965. This issue, now accepted as the authoritative annual publication on the nation's space agency, will examine the National Aeronautics and Space Administration's current and future projects and facilities.

After a year of spectacular achievement, including Astronaut White's record extravehicular space walk, NASA is looking ahead to its new space programs. Special emphasis is placed in this issue on the Apollo Extension Systems (AES) which have an estimated total cost of over $1 billion, and project Voyager, which will explore Mars, Venus and other planets.

This special issue will also explore NASA's plans for other new projects as the U.S. space program begins its swing away from the exploration of the Moon to the vaster and more challenging mission of probing the planets.

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Publication Date: November 29, 1965 **Closing Date: November 15, 1965**

ERC Will Issue First Major RFP's Soon

Some two dozen proposal invitations expected to be out by end of September, under contract by first of December

by Micheal Getler

CAMBRIDGE, MASS.—NASA's Electronics Research Center here now is processing some two dozen requests for proposals (RFP's) that will mark its first burst of major activity with Fiscal Year 1966 funds.

The RFP's are expected to start going out to industry within the next three weeks. All of them should be out by the end of September, and all studies are expected to be under contract by about Dec. 1.

The contracts will be centered within five of the 10 ERC Laboratories—Guidance, Control and Information Systems, Microwave Radiation, Space Optics, and Instrumentation Research.

Two other laboratories—Components Technology and the Qualifications and Standards—will have a smaller level of activity within this first major FY '66 effort. Three labs—Computer Research, Power Conditioning and Distribution, and Systems—have no procurements currently being processed by ERC, according to planners here.

These planners stress that the current imbalance in terms of laboratory activity characterizes only the early phase of the FY '66 program, and is tied to questions of staffing and differences in the pace at which individual laboratories have moved to get their programs under way. Furthermore, they say, the contracts are not necessarily indicative of the relative technological priorities within the laboratories. The only lab which will distinctly lag throughout the FY '66 program, both financially and contractually, is Power Conditioning and Distribution.

In FY '65, its first year of contractual research undertakings, ERC let 33 contracts worth a total of about $2.5 million. The average dollar value was about $59,000, with the largest single award being $285,000. In FY '66, ERC expects to let 60-70 contracts from an R&D budget of approximately $5 million. However, ERC planners say that out of this figure will come expenditures for some special-purpose lab equipment, possibly amounting to 10% or more of the R&D allotment.

● **West Coast reassured**—An interesting sidelight of ERC's first year in business comes to light in examination of the geographical distribution of its contract awards. Of the 33 contracts let by ERC, which was born amid shouts of political chauvinism, 14 went to California firms and only three went to Massachusetts-based companies. The West Coast contracts were valued at $765,844, almost one-third of the total spent by ERC. New York was second in number of awards with six. Minnesota and New Jersey got two each, and six states—Connecticut, Florida, Maryland, Mississippi, Ohio and Pennsylvania—got one each.

While obviously ERC was trying to "bend over backwards," as one planner states, in order to stress that the Center was indeed national in its scope, there was another major reason for the heavy West Coast success. NASA officers at ERC point out that the Center received generally between 25 and 35 proposals on virtually every one of its RFP's—an inordinately large number especially in light of the size of the contracts being let. In many cases, planners here note, major aerospace companies went after business which, had it come from another NASA Center, would not have evoked a response. "Some companies obviously bought in to ERC in order to get some exposure at the new Center."

In the flurry of RFP activity expected to emanate from ERC in September, the individual laboratories will ask for proposals in the following areas:

● **Guidance Lab**—Contracts will be let for gas-bearing gyro research, where ERC scientists are interested in developing techniques to avoid gyro failure associated with system power loss, and in developing improved bearing stiffness of gyros which could be used in strapped-down, high-slew-rate guidance systems.

Another contract will be for studies of strapped-down guidance systems, an area which many spacecraft designers feel will lead to the more simplified, high-reliability systems needed for future long-duration missions.

Actually, the major current contractual emphasis within the lab early in FY '66, according to NASA sources, will be in the area of guidance theory and trajectory analysis. Especially of interest is work in thrust control of low-thrust motors and in generally refining the flight equations and programming associated with interplanetary ventures.

● **Control and Information Systems Lab**—Contracts to be let by this lab next month will center in spacecraft display and control and information theory analysis, say NASA officials here. The latter area eventually will embrace broad research into adaptive, self-organizing, and other forms of information techniques in support of both manual and automatic control systems.

● **Instrumentation Research Lab**—Four projects are ready within this group, including development of what is likely to be ERC's first spaceflight project. ERC planners told M/R that the lab would put out RFP's for a spaceborne instrument to measure space-capsule contaminants.

The instrument will be hand-held by astronauts and will go aboard one of the early manned *Apollo* flights. The request that ERC look into this reportedly came from the Bio-Technology Div. at NASA headquarters.

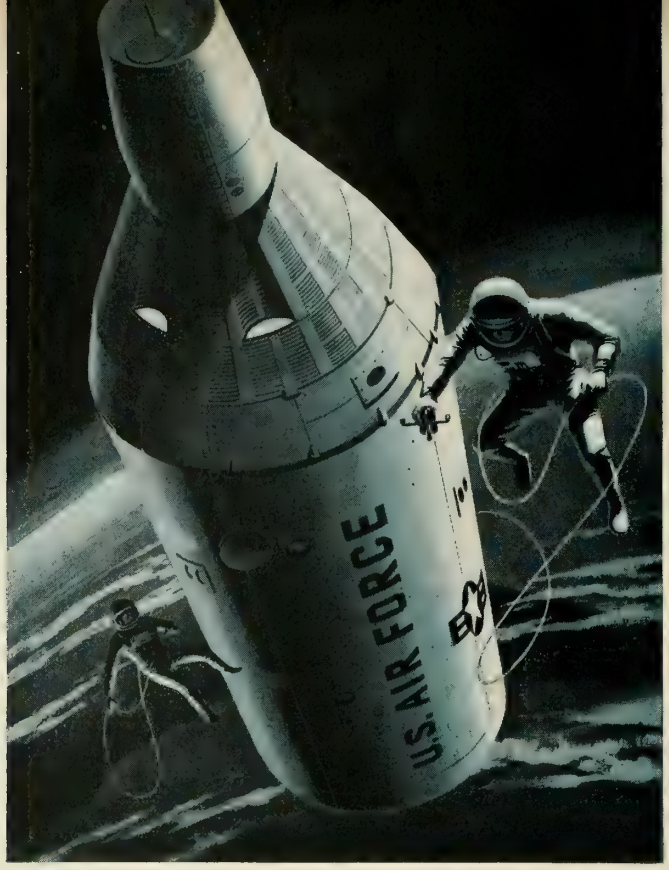
Also from this lab—which actually is ERC's first functioning facility, having its Van De Graaff generator in operation at a Watertown, Mass., site—contracts will be let for work on planetary atmosphere sensors, remote monitoring of physiological conditions, and for very high temperature sensing equipment for rocket nozzle measurements to possibly 10,000°C.

● **Microwave Radiation Lab**—ERC planners report that "a couple of contracts" will be let next month in the area of system trade-off studies associated with long-range space communications.

Also due to be supported will be research on plasma conditions critical to the communications function during launch and re-entry, and investigation of new solid-state circuit development.

● **Space Optics Lab**—Initial FY '66 contract activity will be centered almost completely on laser communications, including materials studies aimed at both new frequency possibilities and higher reliability, and on studies determining system susceptibilities to radiation.

Within ERC's Component Technology Div., which includes the Qualifications and Standards Lab and the Components Technology Lab, there are two small efforts which are in the procurement phase at ERC and will be let early this fall. The Q&SL research will be for studies of failure mechanisms associated with microcircuits, and the CTL effort will be some very basic research into magnetic flux quantization and its possible applications. ■



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Raytheon is producing the on-board guidance and navigation computers and their associated displays for both the Apollo Command Module and the Lunar Excursion Module. This proven technological competence plus a complete systems analysis and design capability is being applied to conceive, direct, and integrate a broad spectrum of aerospace programs.

For more information regarding Raytheon's activity in the field of advanced space systems, write: *Manager of Marketing, Space and Information Systems Division, Raytheon Company, Sudbury, Massachusetts.*

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Technical Countdown

MATERIALS

Wet Wing Check Time Almost Eliminated

A mobile ultrasonic inspection device developed by Automation Industries, Inc.'s Ultrasonics Div. for the Air Force checks out integral wing fuel tank corrosion in military aircraft without materially affecting the aircraft's operational status. Tests conducted by AF scientists at the Research and Technology Division's Materials Lab, Wright-Patterson AFB, strongly indicate that the device will completely eliminate the need for draining and purging fuel tanks for corrosion inspection. The unit has been checked in operation with C-124, C-130, KC-135 and F-102 aircraft. In one case, the device detected corrosion while visual inspection revealed some 5% of the total affected area. This covered C-130 overlapped metal joints. Since integral wing tankage is an essential part of the aircraft structure, such corrosion is far more dangerous than mere fuel leakage. Present inspection methods call for complete fuel drainage, purging and tank entry—and, in some instances, sealant removal—all of which involve operational down-time just for detection. Ultrasonic checks have been confirmed by X-ray inspection. The approach has detected corrosion in riveted joints; the Air Force plans to extend the method to cover large booster cases and honeycomb bonds in large cargo aircraft. Materials Lab is working with the Logistics Command to speed procurement for operational commands. The device is expected to cost about $40,000 per unit.

PROPULSION

Air Force Considering Mach 4 Hybrid Drone

A target drone designed to test the operational mettle of the F-111 and its pilots may be powered by a hybrid propulsion system capable of reaching Mach 4 speeds and altitudes of 100,000 ft. The drone will necessarily involve thrust modulation and fairly sophisticated guidance to simulate realistic combat situations. The ground rules in procurement of target vehicles are centered on economics. Since the U.S. has not yet flown an operational hybrid propulsion system incorporating any of the recent advances in the propulsion technology, the cost factor involved is extremely significant.

SPACE MEDICINE

Research Tool at SAM Improved

The human centrifuge at the School of Aerospace Medicine, the only currently operational human centrifuge in the Air Force, is being modified with a new gondola for a number of AF and NASA programs. The device, which weighs 1,400 lbs. and measures six feet in diameter by nine feet in length, can spin horizontally up to 80 rpm while the main centrifuge is rotating at 53 rpm. Automatic programming, new pilot controls, and the capability of increasing the onset rate of acceleration from one g per second to six g's per second have been installed.

ELECTRONICS

Improved IC Memory in Development

Through use of metal-oxide semiconductors, the Bunker-Ramo Corp. hopes to develop a very-low-power space guidance computer for the Air Force. Heart of the effort is aimed at developing an advanced memory unit using batch fabrication techniques to assure lower cost. Present goal is a 1,000-word (30-bits each), 2 microsecond-cycle memory and a 2,000-word memory unit design. Metal-oxide memory cells are diffused, in the B-R approach, onto a single integrated chip, measuring 100 mils square and containing from 16 to 24 cells each. These are ultrasonically bonded to a substrate carrying deposited interconnections. The existing MOS cells provide a 50-μsec. write time, 20-μsec. read time, and require less than 100 μwatts.

GT-4 Computer Failure Unsolved

IBM still maintains that the failure source in its digital guidance computer used during the *Gemini-Titan 4* orbital mission has not been found—even after over two months of exhaustive test and study. Last June, in the 49th revolution of the two-man vehicle, the computer was operated and then could not be turned off. Immediately upon vehicle recovery aboard the Navy carrier Wasp, the computer was removed and flown back to IBM's Owego, N.Y., Space Guidance Center to determine failure cause. Despite salt-water immersion, the system was cleaned and continuously tested in an attempt to duplicate the failure. Results were nonconclusive. Thus, the firm has installed a back-up cut-off switch to at least assure equipment turn-off. (Even after reinstalling the device in the *Gemini 4* capsule on June 23, the failure could not be duplicated, according to NASA officials.)

Fuel Cell Test Facility Completed

A space fuel cell test facility is in operation at the Air Force Systems Command's Aero Propulsion Lab. at Wright-Patterson AFB. Two analyzers will operate and record the performance of such cells continuously. The equipment, developed by Allis Chalmers, includes a 4-cell and a dual 33-cell analyzer. The 33-cell unit has two consoles and a control board. One console contains a shutdown panel, a 24-point multi-range voltage recorder and a 24-point temperature recorder. The second console has a digital recording panel, a 24-point single-range voltage recorder and load option. The control board regulates gases, loads, vacuum, and purge. Two 200-watt, 28-volt fuel cell modules are now being tested for an unmanned mission. A two-cell unit will be orbited by the Air Force this summer to test ability to withstand thermal cycling and to obtain voltage information.

Avco Continues IQSY Data Evaluation

Measurements taken by more than 60 nations during the International Years of the Quiet Sun will be analyzed and evaluated by Avco/RAD under a 12-month contract with the National Science Foundation. The contract is a continuation of work performed by the Research and Advanced Development Division for the Foundation over the past three years. The IQSY began Jan. 1, 1964, and will end Dec. 31, 1965. Studies of ionospheric, auroral and geomagnetic phenomena will be covered in the $69,228 contract.

LOOK WHAT'S HAPPENED TO MARQUARDT'S "FLYING STOVEPIPE!"

SCRAMJET OPENS NEW ERA FOR AIRBREATHING PROPULSION

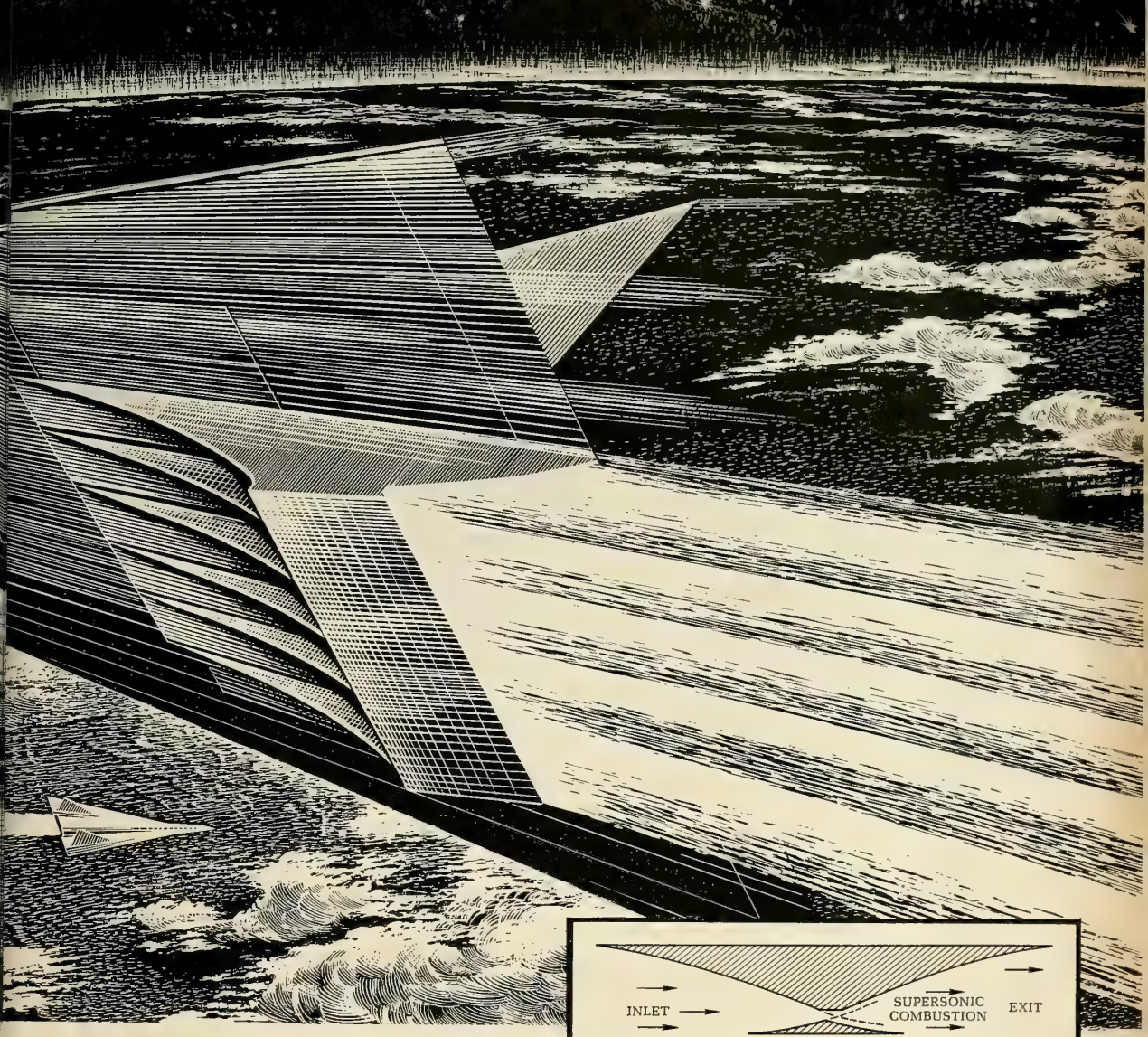
FIRST, THE SUBSONIC RAMJET: Marquardt produced America's first operational subsonic ramjet in 1945. A clean and simple aerodynamic tube, it was aptly described as a "flying stovepipe."

THEN, THE SUPERSONIC RAMJET: To achieve supersonic capabilities, the ramjet engine became necessarily more complex. Diffusers, sensors, inlets, controls, grids, flame holders, exit nozzles — each representing a significant development — served to improve the efficiency and quality of internal air flow, compression, combustion, and thrust. This engine today powers the Bomarc interceptor missile. The supersonic ramjet engine, which has no rotating parts in its operating cycle, remained a relatively simple airbreathing propulsion system — but it no longer resembled the old "flying stovepipe."

AND NOW, SCRAMJET: Today, airbreathing technology has entered the era of SCRAMJET—a propulsion system using to full advantage the ramjet's inherently simple fixed geometry design for hypersonic acceleration and cruise performance—a return to the classic simplicity of the "flying stovepipe."

THE SCRAMJET MISSION: SCRAMJET, the supersonic combustion ramjet engine, performs most efficiently at flight speeds above Mach 6; its range capability expands rapidly as its speed increases. Potential new applications for both space and military missions are under study. These include: hypersonic cruise aircraft, recoverable launch vehicles, and defense and tactical missile systems.

ADVANCED RAMJET CAPABILITY: For two decades, The Marquardt Corporation has pioneered simple airbreathing propulsion systems. Marquardt's capability has been enhanced materially by the recent amalgamation with the General Applied Science Laboratories (GASL), Westbury, New York. Under the direction of Dr. Antonio Ferri, GASL has made significant contributions to the advancement of and the renewed interest in airbreathing propulsion, particularly in the hypersonic regime.



HOW SCRAMJET WORKS

In the classic ramjet the incoming air is slowed down to subsonic speeds, mixed with fuel, and burned in a low velocity combustor air stream. In the Scramjet, the total process is supersonic: air flow, mixing and combustion. The Scramjet, offers a higher performance capability over a broad Mach range, reduced cooling requirements, fixed geometry, and minimum structural complexity.

OTHER ADVANCED CYCLES: Marquardt's research, development, and production activities in airbreathing propulsion have served as basic building blocks for many new and interesting engine cycles. Individually and in combination, these advanced cycles offer exciting propulsion possibilities for launch vehicles and missiles which will allow improved operational capability. Marquardt is currently evaluating these concepts under active contract.

PROFESSIONAL CAREER OPPORTUNITIES: Marquardt is offering long term career opportunities in airbreathing propulsion technology to experienced aerospace engineers and scientists, test facility personnel and technicians. Qualified personnel are invited to submit resumes to Professional Personnel Dept. 135, The Marquardt Corporation, 16555 Saticoy Street, Van Nuys, California, or to Personnel Dept., General Applied Science Laboratories, Inc., Merrick & Stewart Aves., Westbury, New York. Marquardt is an equal opportunity employer.

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Subliming Solid Thrustor Set for Test

First flight-rated rocket will be used to trigger spin for Air Force satellite; Rocket Research Corp. development termed 'exceedingly simple'

by William S. Beller

THE FIRST flight-rated subliming solid thrustor is set to go into space on the Air Force *OV2-1* satellite, scheduled to be launched on a *Titan III-C* within a month.

Once the *OV2-1* separates from its launch vehicle, four miniature but conventional rockets will be fired simultaneously to set the satellite spinning at 9 rpm. Any loss in the spin rate will be made up from time to time by ground commands actuating the satellite's unique thrustor system.

Called Sublex, this subliming solid thrustor system was proposed 2½ years ago by the Rocket Research Corp. of Seattle, and subsequently developed under a contract with Goddard Space Flight Center.

"In spite of its newness, little risk is involved in using the Sublex rocket on the *OV2-1*," say officials of Northrop Space Laboratories, developer of this space-environment sensing satellite.

Seconding this observation, Dr. Joseph Fedor, Goddard's director of the solid thrustor project, says the operation of the device is "exceedingly simple."

● **From solid to gas**—The propellant is stored as a solid crystalline mass in a tank of any desired shape. A simple filter keeps the solid in the tank and out of the propellant lines and valves. Solid-vapor equilibrium maintains the vapor pressure in the tank. When a thrustor valve is opened, the vapor escapes through a nozzle to produce thrust. The solid sublimes rapidly to replace the vapor that has been released. No combustion, ignition, or catalytic decomposition is needed.

Fedor called the thrustors "a major innovation" in the attitude control of spacecraft. Noting "considerable improvement" over conventional cold-gas systems, he said there is a 50% reduction in control system weight with the subliming solid thrustor, increased reliability, increased specific impulse and long-term storage life.

Several subliming solid propellants are known to have useful properties for propulsion. These all have the low molecular weight necessary for vacuum specific impulses on the order of 60 to 85 sec. Of the propellants considered by Goddard, two have been "successfully employed," according to Fedor. These are Rocket Research Corp.'s Sublex A and Sublex B, each showing 84 to 85 sec. vacuum specific impulse at 100 to 1 area ratio.

Indicative of low-pressure operation, Sublex A has a room-temperature vapor pressure of 7 psia; Sublex B, 1.4 psia. The choice of propellant is based on the desired thrust level.

Reasonable applications of the thrustor are for the long-life attitude control of spacecraft requiring thrust levels from 10^{-6} to 0.10 lbs. Fedor says that for the lower thrust levels, continuous thrust is possible; for the higher thrust levels (0.01 to 0.1 lbs.), a pulsing mode of operation is required so that the heat necessary to sustain the heat of sublimation can be acquired.

● **Another propellant used**—In a recent Goddard study, Richard Forsythe chose ammonium hydrogen sulfide (NH_4HS) from a number of possible fuels. The chemical has a heat of sublimation of 782 BTU/lb., and a density of approximately 0.03 lb./cu. in. Upon sublimination, it decomposes into ammonia (NH_3) and hydrogen sulfide (H_2S), with an average molecular weight of 25.6.

He reported that the subliming solid microrocket tested with this fuel delivered a vacuum specific impulse of between 80 and 85 sec. at a nominal operating pressure of approximately 6.5 psia.

The tests showed that the impulse and thrust generated by the solid subliming propulsion device "did not deteriorate in any way" even after eight months' storage. "The system met the original design specifications very well" on the basis of the thrust data.

But there were some drawbacks with the hydrogen sulfide fuel. The Goddard experimenter found a corrosion problem, leading to failure of the valve. "Materials incompatible with this particular fuel, such as brass and copper, could not be used with this propulsion system where they may come into contact with the fuel vapors."

The *OV2-1* is required to attain and keep a spin rate between 3 and 10 rpm over an operational life of one year. To maintain the spin rate, the Sublex system was made with utmost simplicity: two nozzles, a solenoid-controlled valve, a low-pressure tank subassembly and gas distribution plumbing comprise the hardware. The Sublex solid fuel readily sublimes to generate the gas stored in a tank. With the outlet valve closed, the gas is formed until an equilibrium pressure is reached. When a ground command opens the valve, the gas flows out at a rate determined by the characteristics of the two spin-up exhaust nozzles.

For a fuel-tank temperature of 70° ±20°F, an average thrust level of 10^{-3} lbs. could be sustained for 45 min. in the *OV2-1*. A year's supply of fuel is stored in the satellite's 60-cu.-in. tank.

● **Heat needed**—Although the subliming solid does not need much heat input to generate the gas, it does require some. At one time, a radiant energy source was included in the fuel tank (M/R, Sept. 28, 1964, p. 18). This led to the "valveless" rocket. When the radiant energy source was turned on, sublimation occurred, and the resulting vapor flowed out through a nozzle, creating thrust. The thrust could be stopped by cutting off the radiant energy.

By the same token, the system could be pulsed by on-off sequencing of the radiant heat source. Thrust levels of 10^{-4} to 0.1 lbs. were projected, with theoretical specific impulses of about 84 sec. and a propellant density of 0.05 lbs./cu. in.

Other ways of heating the solid fuel: solar radiant energy, ambient internal heat of the satellite—the *OV2-1* method; electrical resistance coils wrapped around the fuel tank; radioisotope capsules; and through the waste heat of other power-generating equipment.

An easy way to soak up solar heat would be to contain the fuel in booms extending out from opposite points on

a satellite diameter. This would not only expose a large lateral area to the Sun but also would magnify the effect of the satellite thrust, increase the satellite roll moment-of-inertia over the transverse moment-of-inertia, and thereby increase satellite attitude control and stability.

Fedor points out that this flexibility of packaging the subliming solid thrustor has been appreciated only lately. With the usual cold-gas system, the designer was usually restricted to the spherical tank because of its high-pressure resistance. The tank, too, because of its awkward shape, often had to be placed within the satellite body.

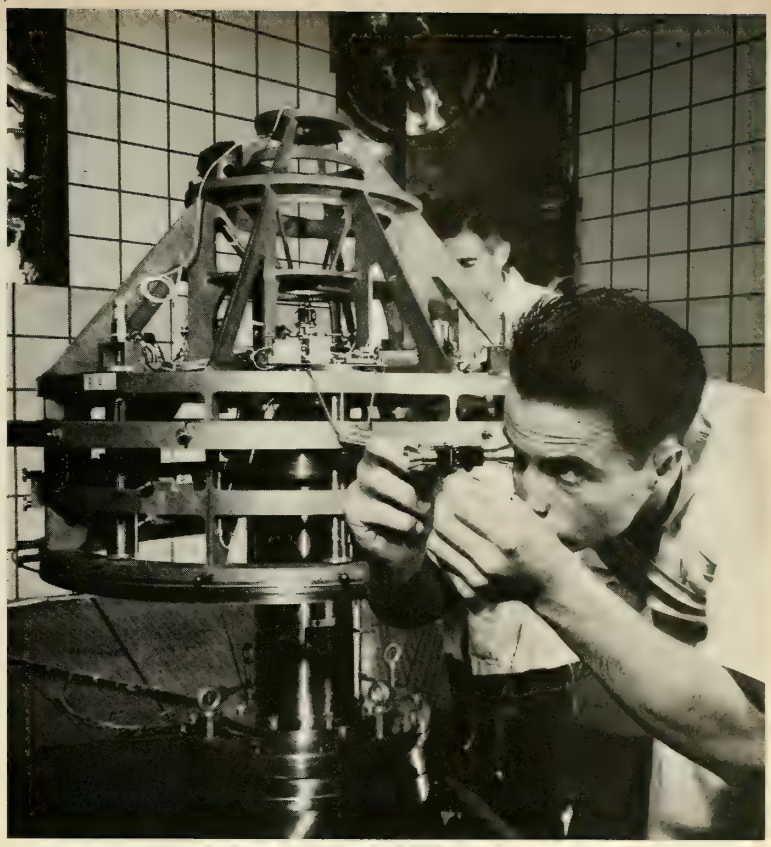
● **Hybrid power**—The Goddard engineer sees a "bright future" for the subliming solid thrustor. He suggests, for example, combining it with a radioisotope thermal generator. These generators normally operate at a high temperature, about 1,500°F, and the heat-power generated is more than 20 times the rated electrical power. Thus, a large amount of the power is rejected to a radiator. Goddard is studying the use of such a combined system in a galactic probe.

Fedor suggests using this rejected heat as the heat of sublimation, and also to heat the generated gas before it passes through the nozzle. He foresees this technique increasing the specific impulse by a factor of two, to about 160 sec. It would therefore be able to compete with more exotic fuels to achieve an attitude-control rocket with substantial thrust.

Goddard is planning to use a subliming thrustor attitude-control system on the anchored *IMP* satellite (lunar scientific orbiter), and also on a follow-on *IMP*. In addition, Francis Federline, a Goddard engineer working with Dr. Fedor, is currently studying in the space center's dynamic test chamber, a spin-up, spin-down subliming thrustor system mounted in a satellite which is set to spin on an air-bearing.

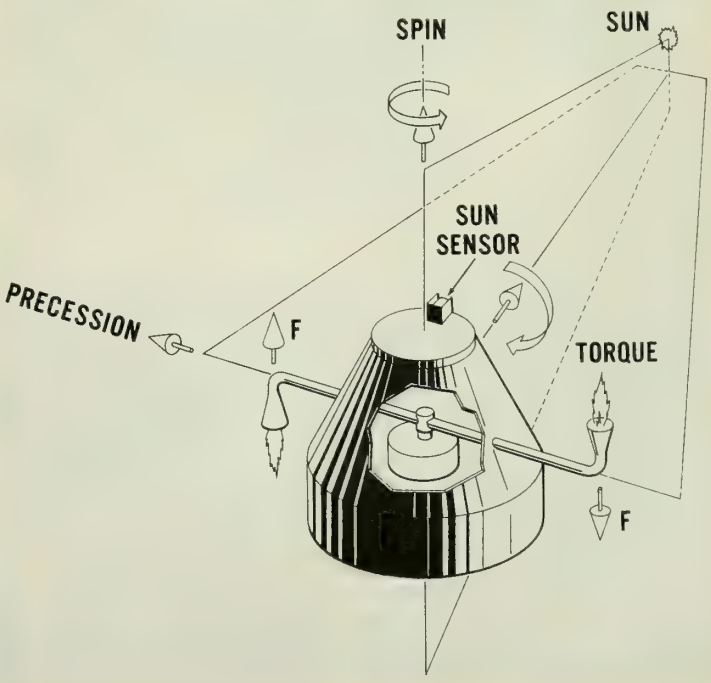
One advanced application of the thrustor calls for orienting a spinning satellite toward the Sun. This is done by means of a Sun sensor, which actuates a pair of oppositely directed nozzles every revolution of the satellite. The pulsing torque that results translates itself into a precession of the satellite until it points into the required direction (see diagram).

The *OV2-1* satellite, on which the first subliming solid thrustor will ride, was developed and built for the Air Force Office of Aerospace Research. It will carry 14 experiments looking into various facets of the radiation environment of space. It is expected to operate for a year and give data that will be useful in protecting astronauts from the biological hazards of the lower Van Allen radiation belts. ■



SPIN-UP/SPIN-DOWN nozzles of solid subliming thrustor used in Goddard test.

SOLID SUBLIMING thrustor precesses satellite axis into Sun-satellite line.



Ceramic Whisker Output Boost Seen

New Jersey firm produces virtually all such single-crystal fibers now available; drastic price slash would follow hike

by John F. Judge

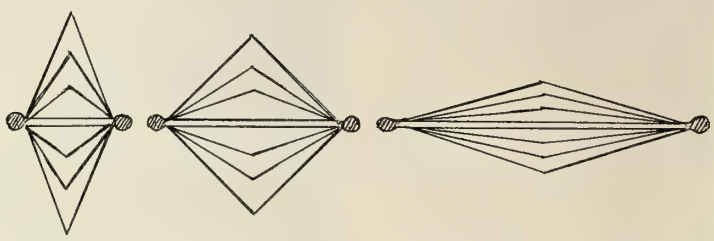
NUTLEY, N.J.—Ceramic whisker production will pass the 10- to 20-lb. per week level by the end of this year in a small U.S. plant—essentially the world's production of such single-crystal fibers.

Thermokinetic Fibers Inc. is running a current production level of some 1 to 2 lbs. of whisker material a week —with an easy target of 20 lbs. by the end of 1965.

"We can increase production by a factor of 10 every six months if the demand for single-crystal fibers should call for this," says John V. Milewski, Thermokinetic vice president.

The firm can expand with little trouble to the 100,000 lb. level per year with a corresponding drop in the price per pound of the so-called rare material.

The fibers now cost as much as $9,000 per pound, but increased production can bring this down to below $100 a pound in two years and in the $20 to $50 range in five years. Ultimate cost should plummet to the $1.00 per



	CERAMICS	METALS	PLASTICS
Ratio of the modulus of the fiber to matrix	2–1	5–1	100–1
L/D (aspect ratio) required for optimal reinforcement	10–20 to 1	20–50 to 1	30–100 to 1
Matrix elongation	Poor	Good	Excellent
Whisker to matrix bond	Excellent	Poor Needs Coating	Good

THE THEORY OF REINFORCEMENT from discontinuous fibers relies on the transference of the load through a matrix. The diagrammed areas around the fibers above are indicative of the particular matrix materials using the same whisker. These lobes are dependent on the ratio of the modulus of the fiber to that of the matrix. The adjoining whisker should mix lobes for maximum reinforcement. The lobe effect has been demonstrated by Schuster and Scala at Cornell. The general lobe characteristics differ from matrix to matrix.

A Primer of Whisker Characteristics

WHISKERS are fine, single-crystal fibers having a polygonal cross-section and a high degree of structural perfection. These fibers display completely different physical properties from their bulk counterparts because of the relative freedom from or containment of dislocations inherent in their small size.

Whiskers are an order of magnitude smaller than glass fibers—ranging in the 0.5 to 30 micron width area. Whiskers are not continuous filaments. Current lengths run from a fraction of a millimeter to several centimeters.

The material is grown by two different mechanisms—basal or tip growth. In basal growth, the atoms migrate to the base of the whisker and extrude the whisker from the substrate. Ceramic whiskers are formed by tip growth at temperatures usually high enough so that the vapor pressure of the whisker material is significant, although Shyne says that growth rates indicate the ions are first absorbed on the sides of the whisker and then migrate to the tip.

Shyne says the morphology of growth has pronounced effects on the mechanical properties and fracture modes of whiskers. Sapphire whiskers are alpha aluminum oxide and belong to the rhombohedral (trigonal) modification of the hexagonal crystal system and have the hexagonal cell as a unit.

Whiskers approach the true cohesive strength found between adjoining atomic cleavage planes, says Shyne. This extreme strength is only displayed by whiskers in which the cross-sections are in the micron area, since such smallness results in a freedom from dislocations and an immobility of dislocations.

Silicone carbide and sapphire whiskers have displayed tensile strengths of 2 to 4 x 10^6 psi. Whiskers can be elastically strained as much as 3% without permanent deformation. This is in comparison to less than 1% for bulk crystals.

Whiskers exhibit much less strength deterioration with increasing temperature than the best convenional high-strengh alloys. Sapphire whiskers have tensile strengths of 100,000 psi at 3,750°F.

No fatigue life effects have been observed in whiskers, and ceramic forms can be handled roughly without affecting the strength. Sapphire whiskers can be milled and chopped without strength impairment.

pound level, say company officials.

The price drop will probably not come from any major effort spawned by the U.S. missile and aircraft industry complex. Indications are that dental needs and foreign developments will far exceed the U.S. defense and space demands.

Thermokinetic Fibers is the largest production source for ceramic whiskers in the world and current ability is some eight years ahead of predictions made by experts in every field of materials.

● **Completely proprietary**—The firm's market position is made extremely difficult because not one cent of government money is involved. Thus Thermokinetics personnel could not be admitted to the recent Air Force Materials Symposium in Miami, since admission was restricted to those holding contracts with the Air Force.

As a result, the entire area of whisker-reinforced composites was totally ignored or dismissed for lack of proponents at a meeting scheduled only once every five to six years.

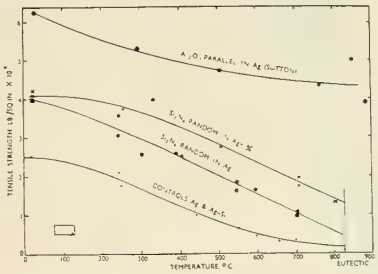
Thermokinetic Fibers—TkF—is producing four distinct and different generic fiber types, together with whiskers in three forms. These are "as grown," milled or chopped. James J. Shyne, president of TkF, describes the current output as "pilot plant" quantities.

Technical literature over the past decade has detailed the potential of such fibers in almost every field of structural engineering. All references have cautioned that whisker material is not a production item nor will it be for at least 10 years. Yet TkF increased world production by several thousand times when they produced less than a pound per week.

Whiskers (see box) are single-crystal fibers whose strengths are equivalent to the forces of adjacent atoms—the ultimate in material ability.

But there are problems. Some of these roadblocks are caused by misconceptions. Others need solid development time and fresh imaginations applied to old approaches, according to TkF.

PARRATT'S tensile results indicate a significant improvement in strength.



Milewski says there are two major fallacies connected with whiskers or small single-crystal fibers. These are that whiskers should be continuous fibers and, in composites, they must be oriented.

Milewski claims these are special cases and govern only when the need for either or both arises.

In support of his argument, the TkF materials expert points to the work accomplished and direction being taken by Dr. N. J. Parratt of the Explosives Research and Development Establishment, Ministry of Aviation, Waltham Abbey, Essex, England.

● **British ahead**—Parratt worked with randomly oriented whiskers using a powder metallurgy technique—and demonstrated significant reinforecment with only a 15% addition of whiskers.

Calculations show that Parratt was able to stress his randomly distributed fibers to about 500,000 psi without coating the relatively weak, low modulus whiskers of silicon nitride.

Previous and current work in using whiskers as reinforcing agents in composites posed problems completely circumvented by Parratt's approach, which opens the door to commercial applications of such reinforcement through powder metallurgy. U.S. work has focussed on the achievement of unidirectional oriented fibers of tungsten wire, large sapphire whiskers and chopped silica fibers.

Unpublished and largely classified efforts in the U.S. are centering on whisker reinforcement as the route to higher temperature aircraft engine turbine blade and bucket development.

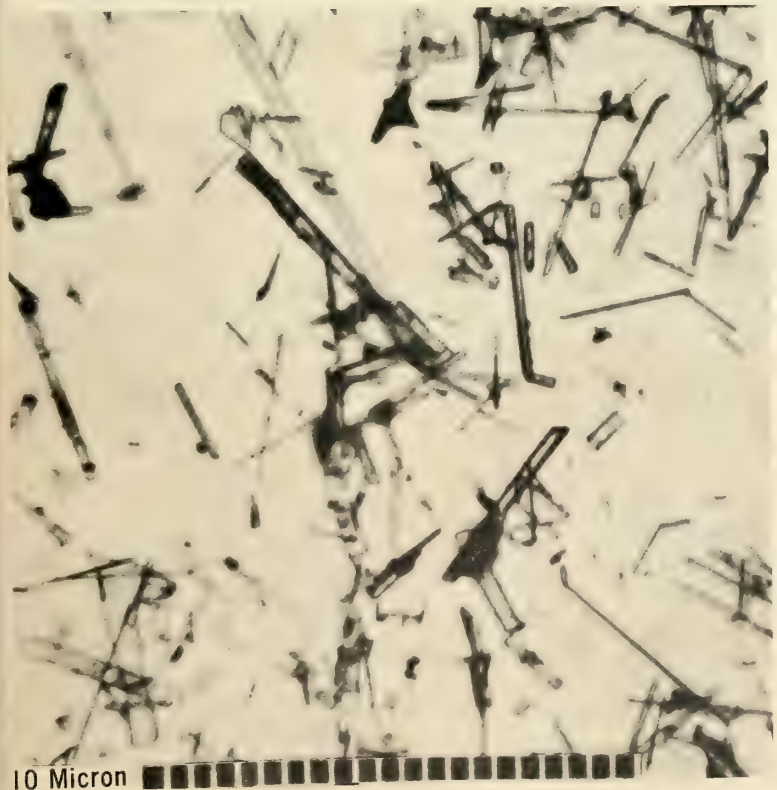
TkF experts consider Parratt's work a breakthrough. The application of whiskers in composites hinges on the development of fabrication techniques —not the development of whiskers. Milewski's problem is educating his many current and potential customers that whiskers are available in production quantities and with a demonstrable uniformity and reproducibility.

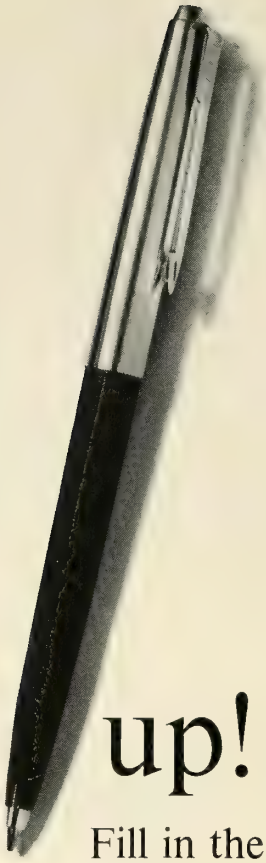
The major problem is making this known and, secondly, driving hard with the point that whiskers offer an immediately usable potential. There is no need to wait until their ultimate theoretical contribution is reduced to production practice in the multi-functional market of composites.

Whiskers operate within a given matrix as a reinforcement as a function of their ability to transfer loads within the matrix. This is not a function of their length, thickness, or direction separately —but directly related to the length/diameter ratio—or L/D—of a given fiber.

There are two practical problems in the creation of composite materials—

LOOSE sapphire fibers manufactured by TkF show ribbon-like structure characteristic of such whiskers. These are 1 to 30-micron-dia. fibers.





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Aero/Thermo
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Life Support and Environmental Control
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Electrical Engineers
Automatic Test Systems. Requires experience analyzing design requirements to control product quality.

Structures
Structural elements, thermal protection systems, pressure vessels. Conceive, design components/systems.

Propulsion Design
Set design criteria and evaluate solid and liquid systems.

Advanced Propulsion systems
Set preliminary design criteria for solid and liquid systems.

Control Systems Engineers
Design, analysis: Nike-Zeus, Thor.

Ground Support Equipment
Design & test ground support equipment. Design electrical systems.

Chemist/Chemical Engineer
Design, develop: Electrochemical, life support devices and pre-treatment techniques for waste fluids.

Chemist—Fuel Cells
Applied electrode technology catalysis, or electrochemical technology.

Mathematician
PhD. Help make new, special purpose computers/programs.

Battery Technologists
Design, fabricate, test: High energy density batteries, electrodes, separators, cases, seals, components.

the uniform distribution of the reinforcement (or the controlled distribution thereof) and bonding the individual reinforcement members to the matrix.

Milewski's stand is that distribution and bonding are greater problems than orientation and length. In some cases, depending on the matrix and the whisker material, bonding is impossible without some intermediate coating or reaction. But there is an equal number of cases in which bonding can be direct—without coatings—if processing imagination is used. The prime example is the work by Parratt.

● **Co-dispension approach**—Parratt prepared his composites in a household-type blender by mixing short, fine whiskers in a slurry containing the metal powder. The slurry was cast out, dried and then vacuumed and hot pressed into small sheets. These were then machined into tensile bars.

Parratt's results are shown in the graph together with Sutton's results at General Electric's Valley Forge Space Center.

A third method of utilizing whiskers —other than parallel and Parratt's co-dispersion technique—is the impregnation of whisker felts and paper. Since the advent of whisker paper, methods include slip casting of ceramics and metal powders into paper felts and the impregnation of paper felts with plastics in liquid form. Vapor plating into such mats has also proven successful with metals.

● **Ceramic composites**—Milewski says that six dental schools are initiating extensive research in whisker-reinforced dental porcelain, plastics and metal-filling material. Significant data in ceramics have evolved from preliminary work by Dr. R. N. Boyd III at New York University directed at solving the problem of ceramic porcelain's weakening after pigment additions.

Dr. Boyd has demonstrated that small additions of whiskers added to his pigmented ceramic porcelain has been able to restore the material to its original, unpigmented strength.

Milewski admits this work is far from optimum but it is a valid indication of a direction previously unavailable.

Another area of immediate application lies in glass fiber filament winding. It also applies to boron-wound structures. Studies are in progress at the Naval Ordnance Lab involving additions of whiskers to filament-wound rings.

The object is to reinforce the interstices among filaments by adding loose whiskers to the resin before wet winding. This develops a higher packed density. Preliminary tests with 1% additions have resulted in a 20% improvement of interlaminar shear and an increase in the allowable compression stress in the glass by 59% to a value of 359,270 psi.

In addition, this approach could be used to strengthen those sections of filament-wound structures in which holes or other discontinuities are necessary.

● **Potential**—Milewski expects whiskers can contribute to ceramics by adding toughness and changing the failure mode—lessening the brittle fracture. The TkF executive outlined four major contributive areas.

—Sub-micron whiskers should be considered as a modulus booster and an internal reinforcement in drawn glass fibers. A 10% addition could boost the modulus by 10 million psi.

—Small concentrations of whiskers (0.1-1%) could be used as recrystallization directors in Pyroceram-type glass compositions. When the glass recrystallizes, the crystallites should form on the whiskers and produce rod-like grains rather than random spherical grains. This pseudo-fiber structure would improve both the mechanical and thermal shock properties.

—Whisker additions of 5 to 10% in slip cast ceramics would result in better green strength, mechanical reinforcing for elevated temperature use, grain refinement for long-term service and improved shock resistance.

—The ultimate use of whiskers would be in 90-95% compositions with a ceramic binder. One suggested process should result in a wafer-thin ceramic with about 1,000,000 psi and a 2-3% elongation.

TkF will remain a materials supplier, but the development of the many potential markets for whiskers has involved the firm in learning various fabrication techniques.

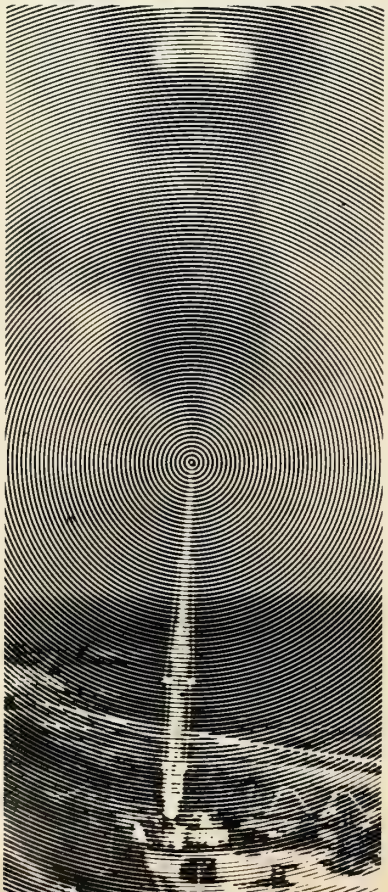
For instance, Milewski and Shyne suggest one possible route to oriented whiskers in plastic tubing would be to add whiskers to the monomer, catalyze and draw the polymerized material into filaments. Material flow through the drawing dies will orient the whisker in the same manner as it does the polymer chains. The result is a filament with a 1-million-psi strength.

The manufacturing processes used at TkF are proprietary. Shyne says the growth of the whiskers is visible to the eye and the process itself takes minutes.

TkF produces wool mats, paper and loose fibers in sapphire as well as sub-micron fiber clusters and sub-micron blades. The firm also produces wool and crystals in silicone carbide and aluminum nitride-oxide.

Shyne and Milewski say production of single crystal fibers is well in hand and any expansion makes use of processing equipment already developed for other basic industries. Raw material is extremely cheap and the whisker price is totally dependent on demand. ■

NEW SPACE BOOSTER



Fulfilling Jules Verne's prediction, giant cannon twelve stories high are being used in the development of a new kind of space-launch system. ☐ In recent tests at Barbados Island, the specially modified 16-inch Naval guns successfully fired two Martlett 3-B motors containing 120 pounds of live rubber-based polycarbutene propellant. Peak gun pressure exceeded 35,000 psi, causing an 8,000 G acceleration load on the solid propellant-loaded projectiles. The firings for Project HARP (High Altitude Research Program) were designed to test the propellant grain design and new case bonding techniques developed by Lockheed Propulsion Company. ☐ The successful tests point the way to solution of a primary problem of gun-launched rocket technology: supporting the propellant grain against acceleration loads during firing. It brings closer to reality a low-cost replacement for the present expensive and non-recoverable first stage of scientific space vehicles. And it holds promise for anti-missile missiles—as well as new, very long range artillery. ☐ Expanding programs at LPC, such as gun-launched rocket systems have created excellent career opportunities for highly qualified propulsion engineers, scientists in research, engineering, product assurance and manufacturing. ☐ You are invited to write Professional Employment Manager, Department 5208, Post Office Box 111, Redlands, California. Lockheed is an equal opportunity employer.

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Sylvania Steps Up IC Market Drive

Firm sees variety of applications for its new solid-structure microwave germanium tunnel diode; expansion continues

WOBURN, MASS.—Sylvania's Semiconductor Div., whose officials say that the firm is determined to become a leader in the integrated circuit field, has expanded its line of available circuits and is about to embark on the second phase of a five-part plan to expand its manufacturing capabilities in this field.

The firm also reports development of a new solid-structure tunnel diode that engineers here feel should have special appeal for a variety of space applications.

The new integrated circuits consist of a family of seven gates and two flip-flops, which represent the next generation in Sylvania's Universal High Level Logic (SUHL) line, all of which is TTL (Transistor-Transistor-Logic). The first 18 SUHL circuits were introduced last year by the firm.

The new circuits, which Sylvania says are totally compatible with the standard 18 circuit line, are roughly twice as fast as their predecessors and represent "the fastest saturated logic available," according to the firm.

The SUHL-II circuits are designed for applications to 40mc, according to Alvin B. Phillips, general manager of the firm's integrated circuit operation, and have gate propagation delays on the order of 6 nanosecs. The SUHL-I circuits are designed for applications to 20mc, with gate delay times slightly above 10 nanosecs. Average power dissipation per gate for SUHL-II is reportedly 20-30 milliwatts, an increase from the 15-milliwatt figure associated with the SUHL-I line.

According to Phillips, stable logic swings and propagation times are maintained in the new line over a temperature range from —55° C to 125° "without recourse to additional bias supplies, complex loading rules, and external clamping and shielding. Low power OR expansion is accomplished without degradation of fan-out and without capacitively loading the gate output," according to Phillips. Fan-out capability of the new line extends to a minimum of 12 additional gates.

The SUHL-II line is now in production at Sylvania's new integrated circuit facility here, and a few thousand of these devices have already been delivered, says a Sylvania engineer.

Accompanying introduction of the SUHL-II line is a small, new, hermetically sealed, alumina-filled glass plug-in package for the circuits, designed for manual or automatic insertion into double-sided printed circuit boards.

While the SUHL line is also available in flat-pack configuration, engineers here say they see a large industrial and commercial market where flat pack assemblies will be far less desirable than a plug-in type.

● **Expansion plans**—Sylvania's expansion of effort into IC production began last year as part of a five-phase program. The new IC facility at Woburn now occupies close to 50% of the division space and will be capable of turning out 100,000 circuits per month by the end of this year, according to the firm. Sylvania officials, however, decline to release figures concerning how many circuits are actually being produced and delivered.

The first phase of this IC expansion cost the firm about $3 million, according to informed sources here. The next four phases, the second of which is to get underway "in a few weeks," will probably be less expensive. Sylvania's Phillips told MISSILES AND ROCKETS that plant capability will be tripled to 300,000 circuits per month by the end of 1966 and that 8-10 million circuits annually would be within the facility's capability by 1969. Phillips says the firm is aiming at breaking into the "top four" in the IC production field by 1970.

Sylvania officials say they expect their IC operation to reach a profitable status in about 18 months.

● **Diode development**—Sylvania also has laid claim to "the first solid-structure microwave germanium tunnel diode," a device project engineers see as a major breakthrough in microwave device reliability. These devices, now being manufactured in small quantities at Woburn, have been successfully tested in temperature extremes ranging from liquid nitrogen temperatures to 100° C. More conventional tunnel diodes, according to Sylvania, normally run into trouble at temperatures above 70° C.

The technique, which involves thin-film batch processing of 2 X 3cm germanium wafers, each of which produces 3,000 devices, has been developed under company funds during the past 6 to 8 months, and has also had some support from the Air Force Rome Air Development Center. The RADC effort reportedly involves reflective-amplification balloons used for space communications, for which highly reliable microwave devices able to function under severe temperature cycling may be required.

Use of the thin-film evaporative process to lay down the metal alloy junction layer, a protective oxide layer (which also provides contact support), and metal contacts top and bottom, has enabled Sylvania engineers to overcome what they consider to be the major problems that have plagued microwave tunnel diodes up until now—namely the high cost associated with the hand-made aspects of conventional techniques and the reliability problems caused by the fragile and very narrow device junctions.

Sylvania estimates that the new technique will provide TD's for 50 to 60% lower cost than the methods it now uses to provide devices with similar characteristics in some categories. The firm says it intends to phase out of its present method of TD production by the first quarter of 1966, converting to the new thin-film batch processing technique.

Engineers here say the thin-film method allows the addition of passive components, makes for easy integration of the TD into microwave circuits, and also allows selling the device as an unpackaged die, since it needs no external support. While there is basic design advantage to the circuit engineer in having these available in unpackaged form, says Sylvania, there are additional advantages in this form in terms of eliminating some capacitance and inductive mounting problems, which can limit bandwidth. ■

NASA Gets 'Biolab' Recommendations

Lockheed study suggests measurements and proposes equipment for conceptual spacecraft including AES, MORL and Apollo-X

by Heather M. David

FINAL RECOMMENDATIONS for an integrated biomedical and human-performance measurements laboratory for the *Apollo Extension Systems (AES)* have been delivered to NASA by Lockheed Missiles and Space Co.

The study is one of several aspects of the second phase of NASA's program on post-*Apollo* missions. The Lockheed study, entitled Biolabs, suggested kinds of measurements to be made and offered equipment recommendations for several conceptual spacecraft, including *AES, Manned Orbiting Research Laboratory* (*MORL*), and *Apollo-X*. In each, it was assumed that a main objective of the space station would be the study of man's response to the space environment.

The report is now being evaluated in the Office of Manned Space Flight's advanced missions group to determine whether to proceed with further development or study. Purpose of the contract, according to program monitor Dr. E. J. McLaughlin, was to give NASA some idea of the kinds of equipment and tests that could be incorporated in such a spacecraft system. The equipment recommendations do not, of course, represent NASA's final choices.

As envisioned by NASA, such a space laboratory would have a physician among the three astronauts aboard. As in the Soviet *Voskhod* spaceflight in October, 1964, the presence of a physician would greatly simplify the data-handling problem, enabling a greater yield of space information and transmission of results instead of raw data.

Configuration of the *AES* biological and human-performance laboratory, as outlined by NASA, would be the Configuration-C *Apollo-X* spacecraft modified for 45-day missions. This would include the *Apollo* Block II Command and Service Module, the Lunar Excursion Module ascent stage with the ascent propulsion system removed, and a LEM descent structure, which would serve as a storage area for expendables. This would make available 242 cu. ft. and 800 lbs. for experiments—which would be performed in the LEM laboratory.

Among the features Lockheed recommends:

—Integrated biomedical console and biometric jig for physiology measurements.

—Mass measurement system capable of giving astronaut weight to within 1-lb. accuracy, even in the weightless condition.

—Human-performance console with complete psychomotor and performance testing capability.

—Radiology laboratory employing an X-ray tube, image intensifier and onboard vido system.

—Spin-frame (a 3-ft.-radius device for possible use in therapy.)

- **Conclusions**—Lockheed found that the *AES* configuration could accommodate 160 biomedical and human-performance measurements using only 400 lbs. of the total 800 lbs. available for experiments. Another 200 lbs. would be required for the data-management system, although this could be shared with other scientific experiment programs.

With the *Apollo* Command Module unavailable for Biolabs, the LEM laboratory offers a restricted configuration and a limited volume to accommodate the major orbiting research laboratory objectives, Lockheed said.

The company recommended further study of the effects of 100% oxygen on equipment, further definition of experiments and equipment interfaces, and evaluation of the spin-frame as a countermeasure for weightlessness effects.

- **Description**—The LEM laboratory would be divided into two major sections, the main cabin and the mid-section. The main cabin would be the area previously containing the LEM main lunar descent display and control panel, the viewing ports and the main cabin egress/ingress hatch. The mid-section would be adjacent to the main cabin and include the crew transfer and docking tunnel and engine cover.

The main piece of equipment would be a large console located in the mid-section. It would contain the biometric station, the human-performance station, and the micro-chem station.

The biometric station would include displays and controls and recording devices to present data telemetered from biomedical sensors placed on the astronaut. For use, the astronaut would pull out a tray formed like a U-yoke located below the console, pick up the electrodes placed near the inside edge of the "U," and put them on. An electroencephalogram helmet also would be provided.

Physiological laboratory display and control panels would be placed above, with separate panels for the extravehicular activity bioinstrumentation. This would include displays for electrocardiogram readings, temperature, suit-water temperature rise, oxygen tank pressure, suit pressure, suit oxygen inlet pressure, battery current, and two-way voice communications.

On the right-hand side of the console would be the micro-chem station, with an extendable workshelf to provide a maximum workspace area for liquid handling and analysis. Items kept in cold storage in the left-hand compartment would be moved to the Command Module at the end of the mission for return and analysis on Earth.

The human-performance station would be placed on the left-hand side of the console, and include such equipment as an oculometer, a computer entry-key board, a cathode-ray tube system, re-entry simulator display and controls, human-performance displays and controls, a steadiness tester, motion picture camera and a tape recorder.

All major experiments would be performed in the main LEM cabin area. The company said it considered it feasible to perform the tasks of determining mass, making radiological measurements, and possibly utilizing a spin-frame, all within the space available.

The design is intended for a two-man occupancy of the LEM, with the third crew member taking alternate turns in the Command Module. The work/rest cycle developed by Lockheed

for the three members would make available 24 man-hours a day—with the physician spending 10 hours doing biomedical experiments and the other two crew members performing 7 hours' work each. NASA's initial estimate was that only 12 man-hours' total would be available each day.

The main cabin of the LEM would be left for scientific activities. Modifications necessary to the LEM would include removal of engine cover in the midsection, and the shifting of the overhead hatch hinge to the opposite side of the hatch.

● **Physiology laboratory**—The first of the five laboratories NASA asked to have included in the study was a physiology laboratory, to report on the status of processes in human organ systems, with emphasis on the cardiovascular, respiratory, musculo-skeletal and nervous systems.

Lockheed recommended that biomedical monitoring should be carried out twice each day the first week, then once each day thereafter. This would include cardiac state and activity with the use of EKG electrodes, respiration rate through impedance pneumogram, body temperature with thermistors on the mouth and on the skin, blood pressure with aneroid sphygmomanometer, and heart sounds through a microphone over the heart.

Experiments in cardiography should be conducted once every two days for the first week, then once a week thereafter, the study indicated. It recommended measurement of cardiac output by the indirect Fick-Klausen method, EKG measurements and vectorcardiography by the Frank system, and ballistocardiography using a body stabilizer and accelerometers.

Four times a day, the researchers said, exercise should be performed and tolerance measured.

Once a week during the flight, Lockheed recommended, cardiovascular responsiveness should be measured with the use of a thigh venous-occluding cuff, pooling blood in the legs. Heart rate, blood pressure and venous compliance measurements should be taken during this procedure, using EKG, digital cuff and lower-extremity plethysmography. In addition, pulse-wave velocity can be determined using the EKG, and digital cuff and cardiac electromechanical delay can be reckoned with the EKG and phonocardiogram.

Daily respiratory measurements were urged for the first week, then once each week afterward. This would include respiratory mechanics such as pattern, expired minute volume, vital capacity, tidal volume, inspiratory and expiratory reserve, and inspiratory capacity. These could be made by breathing into a spirometer. Incorporated in this device

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would be an analyzer to measure end-tidal pO_2 and pCO_2, alveolar pO_2 and pCO_2.

Muscular status could be determined with a load cell exerciser, performed once each week, Lockheed noted. Muscle size should be measured with tape-measure caliphers, and total body photographs for TV or photo transmission once each week would help determine muscle condition. Once every 2 weeks, the crew members should measure body mass with the use of the mass measuring device, and joint motion with a goniometer. Electromyograms could be taken with electrodes once each seven days.

It was urged that endoradiosondes be used once a week to determine the status of the gastrointestinal system, including its motility, temperature and pH.

For a check on metabolic activity, the study suggested calculations with the respiratory analyzer daily for the first week, then once each week. This would consist of measurements of oxygen consumption and carbon dioxide production using polarographic techniques.

Oxyhemoglobin measurements, using an oximeter that operates by means of the transmission of light through the blood in the earlobe, should be performed daily, according to the study.

For gauging the nervous and sensory mechanisms, Lockheed suggested an electroencephalogram be taken once each week, using a helmet equipped with EKG electrodes. Determinations of the state of the vestibular system would be made with caloric stimulation of the semicircular canals, subjecting the astronaut to body rotation on a stool, and measurements by electronystagmogram. The otoliths of the vestibular system could be checked by a measurement of the threshold of linear acceleration, by putting the subject on the mass measuring device, which has a linear track.

General physiological measurements such as record of intake/output of solids and liquids are recommended. Additionally, the study suggests measurements of body fluid compartments and plasma volume daily for the first 5 days, then once each 7 days, using tritium, a scintillation counter and radioisotope handling equipment.

• **Microscopy and chemistry**—Lockheed proposed a number of tests on serums for various body systems—including musculo-skeletal, gastrointestinal, metabolic, endocrine, fluid and electrolytes, genitourinary, hematology, and general microbiological tests on the blood, throat and skin.

Urine and feces samples would be taken on a 24-hour basis. Blood samples would be drawn by each subject using capillary tubes with spring-loaded blades sealed with hematocrit clay.

Lockheed suggested the use of a number of Ames diagnostic tests—prepared clinical tests that involve color changes that occur when small amounts of biomaterials are introduced to a tablet or paper. These could be put in small plastic bags, through which samples could be injected, and fitted with septums for hypodermics.

Other equipment recommended for use in the microscopy and chemistry laboratory were a colorimeter, flame photometer, gas chromotograph, microscope, and spectrophotometer.

• **Radiology laboratory**—One set of equipment could be used for most measurements, the report said. This would include an X-ray tube, image intensifier, adapter for on-board video pickup, videotape recorder and spacecraft telemetry system. The company estimated that the total system would weigh 73 lbs.

It was felt that one X-ray of the heart and aorta on the first, third, fifth, and seventh days, with weekly exposures thereafter, should suffice for the cardiovascular system.

The same exposure would give information on pulmonary circulation and lungfields, the study indicated.

A second X-ray which Lockheed suggested should be done weekly, would cover the gastrointestinal and genitourinary regions.

A possible method of determining skeletal bone structure would be the X-rays of fingertips, step wedge, and heel bone each week. Bone density also could be measured by differential X-ray absorption, at exposures of 50 and 250 KEV weekly.

Radioisotope measurements for red cell mass, plasma volume and body water also were recommended.

• **Human-performance laboratory**—Some 39 measurements were suggested to cover the status of the astronauts' sensory-perceptual functioning, psychomotor functioning and higher mental processes. These are aimed at determining the relationship between human performance and physiological condition, and at obtaining measurements to detect changes in the subjects' capability to perform mission tasks.

The one performance console would weigh about 60 lbs., take up 2.45 cu. ft., and require 100 watts of power, Lockheed estimated. Vision would be measured by oculometer.

Performance in extravehicular activity would also be measured. The firm lists a number of suggested tasks, such as self-maneuvering by the astronaut, and assembly, repair and inspection tasks. These would require the use of photographic equipment, a timer, a tape recorder, hand recording devices, visual stimulation targets, transmitter, assembly devices and tools, and a torquing device.

• **Centrifuge laboratory**—The fifth laboratory that NASA asked be considered was deemed not feasible for the *AES* configuration. Lockheed, however, studied several possible spin-frame devices that might be useful as weightlessness countermeasures. The company said that it would not recommend their use until much more study is done.

Lockheed did urge adoption of several weightlessness countermeasures, including positive-pressure breathing, using a mouthpiece pressure regulator and a pressurized source of breathing gases.

Another weightlessness countermeasure recommended was compression—standing or walking while exerting a downward force through the use of handrails. A thermal suit with different temperatures for different areas of the body, or a pressure suit with differential temperatures at head and feet might also prove useful, Lockheed said.

The company also developed a device it calls "Exer-Genie," a small metal cylinder with a specially braided nylon line which requires various forces to pull depending upon how it is set. A variety of exercises are suggested.

• **Atmosphere consideration**—Choices of equipment will be affected by NASA's selection of a spacecraft atmosphere, Lockheed points out. For example, the company said, use of 100% oxygen would require redesign of a number of instruments, and extensive redesign of the automatic nitrogen analyzer and flame photometer.

• **Data handling and communications**—The data-management system must be able to handle 160 biomedical quantities, of which the majority would be in the 40-mv or 5-v range.

The combination of frequencies and numbers of quantities to be measured at any time will not exceed 5×10^4 bits/sec., Lockheed said. The equipment on the spacecraft should include a down-link data equipment system, a service, control and uplink data system, a video system, and an audio system. In addition, data-management systems should provide two-way communications, one-way telemetry, and one-way stimulus control for EVA activities.

The communications system should have real-time TV transmission to the ground for monitoring experiments, and a closed-circuit on-board TV system for observation of the astronauts, for the performance of maintenance functions, and for EVA. This, Lockheed recommended, should include color and black and white, with a 30/sec. frame rate on the on-board unit, and 525 scan lines per frame. Video bandwidth would be 2.1 mc. ■

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Mergers and Acquisitions

The boards of directors of Fairchild Hiller Corp. and Republic Aviation Corp. have approved the terms of a proposed sale of Republic's operating assets to Fairchild Hiller. The acquisition is subject to final approval by the stockholders of both companies. Special meetings of the stockholders of both firms have been scheduled for Sept. 29. The Republic board has also approved the sale of the firm's non-operating assets to the Farmingdale Co., a joint venture company composed of A. L. and J. L. Mailman and associated interests. Final prices payable by Fairchild Hiller and the Farmingdale Co. are contingent on Republic's net book value at time of closing. Current estimates, after deduction of Republic's liabilities, which are to be assumed by the purchasers, are that Republic will receive from Fairchild Hiller some $16.5 million in cash and approximately 1,460,000 shares of Fairchild Hiller common stock—one-half share for each Republic share outstanding. Republic is expected to receive about $8 million in cash from the Farmingdale Co. The sales will not include Republic's cash, short-term investments, its holdings in KNVF Fokker, or Republic Aviation International, S.S., a wholly owned Swiss subsidiary. . . . *Ling Electronics, Anaheim, Calif., has acquired the Micro Gee Products, Inc., line of rate tables, acceleration tables and multi-axis flight simulation tables. Ling Electronics is a division of LTV Ling Altec, Inc. Micro Gee Products was an operation of Menasco Manufacturing Co. of Burbank, Calif.* . . . Varian Associates, Palo Alto, Calif., has announced the completion of the merger of Eithel-McCullough, Inc., into Varian. Stockholders of the two firms approved the transaction on July 1. Eithel-McCullough becomes a division of Varian. Eimac shareholders, under terms of the agreement, will receive one share of Varian common stock for each two shares of Eimac stock. . . . *Jacobson Manufacturing Co., Inc., Kenilworth, N.J., has acquired Barwood Manufacturing Co. of Everett, Mass., a manufacturer of self-sealing fasteners and washers, gaskets and stampings for aerospace and commercial applications. Barwood will be known as the Barwood Mfg. Corp. and will operate as a wholly owned subsidiary of Jacobson.* . . . Federal-Mogul Corp., Detroit, has completed negotiations with the W. R. Grace Co. to purchase the assets of the Vellumoid Co., a wholly owned subsidiary. Vellumoid makes gaskets.

Facility Expansions

Wiltron Co., Palo Alto, Calif., designer and manufacturer of communications test sets and advanced test instruments, has broken ground for an 11,500-sq.-ft. building, the first of a planned 50,000-sq.-ft. expansion in new buildings. Most of the new structure will be used for production of a new line of electronics instruments. . . . *Concept, Inc., St. Petersburg, Fla., has moved to new 4,200-sq.-ft. facilities. The move is to make possible expanded development work in the fields of bio-astronautics and biomedical engineering.* . . . Booz, Allen Applied Research, Inc.'s Development and Design Div. has moved to new quarters in Cleveland. The firm's staff and equipment are now housed in a new 26,000-sq.-ft. building, which contains an industrial design center, physics laboratory, electronics laboratory, optical laboratory, machine shop, mechanical laboratory, model shop, technical library and executive offices. . . . *Deltron, Inc., Philadelphia, manufacturer of regulated power supplies, has begun construction on a new 32,000-sq.-ft. plant in Upper Gwynned, Pa. Design of the new facility provides for eventual expansion to 62,000 sq. ft.*

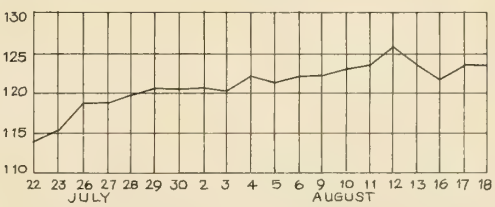
International

CTS Corp., Elkhart, Ind., has negotiated a license agreement with A.B. Metal Products Ltd. of Wales, for the manufacture of microelectronic components and circuits. A.B. Metal Products will organize a CTS Microelectronic Div. in new manufacturing facilities to implement the agreement. The components produced will be aimed at the European aerospace, computer and communications markets.

Engineering Profs Getting Bigger Salaries

According to a survey of 7,000 engineering teachers just completed by the Engineering Manpower Commission of Engineers Joint Council, the average teacher of engineering now earns $13,500 a year—$10,725 through his regular teaching assignment and $2,775 from other professional activities such as consulting and writing. The total income increase represents an 11.7% increase since 1962. The increase over the 1960-62 period was 9.7%. The study shows instructors making on the average, $7675, assistant professors, $10,700, associate professors, $13,275, and full professors, $17,850. Department heads have overtaken full professors in total earnings since the last survey. They now make an average of $18,050.

Missile/Space Stock Index



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$27,200,000—**Radio Corp. of America,** RCA Service Co., Camden, N.J., for services and supplies required for the operation and maintenance of BMEWS.

$24,839,500—**Federal Electric Corp.,** Paramus, N.J., for the Distant Early Warning System.

$12,365,742—**Radio Corp. of America,** RCA Service Co., Camden, N.J., for operation and maintenance of the White Alice Communications System.

$10,000,000—**Lear Siegler, Inc.,** Lear Siegler Service, Inc., Santa Monica, Calif., for aircraft and aerospace system maintenance at more than 45 Air Force installations.

$8,530,750—**General Electric Co.,** Heavy Military Electronics Dept., Syracuse, N.Y., for sensor facilities at the Telemetry Receiving Station, Shemya, Alaska.

$6,705,610—**Sperry Rand Corp.,** Philadelphia, to make electronic data-processing system.

$6,150,000—**Hughes Aircraft Co.,** Culver City, Calif., for modification of *Minuteman* missile test equipment.

$2,570,450—**Radio Corp. of America,** Defense Electronics Products Div., Moorestown, N.J., for operation and maintenance of the Moorestown Tracking Radar Test Facility.

$2,030,822—**Electronic Communications, Inc.,** St. Petersburg, Fla., for four contracts to provide airborne communication equipment for SAC airborne command post.

$1,900,000—**Electronic Communications, Inc.,** St. Petersburg, Fla., for communications equipment and engineering services.

$1,020,387—**Philco Corp.,** Newport Beach, Calif., to operate a laboratory at Vandenberg AFB, Calif.

$85,000—**Decision Systems, Inc.,** Teaneck, N.J., for a computer diagnostic program.

Bell Aerospace Corp., Bell Aerosystems Co., Buffalo, N.Y., to build and test small liquid rocket motors for *Minuteman II* (amount not disclosed).

ARMY

$5,168,000—**Raytheon Co.,** Lexington, Mass., for work on *Hawk* missiles.

$1,700,000—**Union Carbide Corp.,** Charlotte, N.C., for dry cell batteries for use in electronic communications equipment.

$1,600,000—**Raytheon Co.,** Lexington, Mass., for research and development on a self-propelled *Hawk* to use in the forward area of a combat zone.

$400,000—**Whittaker Corp.,** Los Angeles, to overhaul and repair *Nike-Hercules* gyroscopes.

$103,301—**Collins & Fletcher Construction Co.,** Lompoc, Calif., for meteorological system expansion at Vandenberg AFB, Calif.

NAVY

$5,191,711—**Chromcraft Corp.,** St. Louis, for *Mighty Mouse* rocket launchers for use in Air Force tactical aircraft.

$3,165,000—**Sanders Associates, Inc.,** Nashua, N.H., for classified electronic equipment.

$2,000,000—**American Machine and Foundry Co.,** New York City, for self-contained liquid propellant rocket engines.

$1,840,000—**Babcock Electronics Corp.,** Babcock Aerospace Div., Costa Mesa, Calif., for the design, development and fabrication of prototype microwave radio command control equipment for use in testing missiles.

$1,500,000—**The Bendix Corp.,** Systems Div., Ann Arbor, Mich., for electronic modification of the range instrumentation ship USNS Twin Falls, for use on Atlantic missile range.

$1,000,000—**McDonnell Aircraft Corp.,** St. Louis, for classified weapons system.

$500,000—**Stromberg-Carlson Corp.,** San Diego, for special airborne computer display equipment to be used in the development of advanced ASW techniques.

$126,980—**Aircraft Armaments, Inc.,** AAI Pacific Div., Northridge, Calif., for receiver test sets used to monitor and adjust operating frequencies of a *Terrier* missile receiver.

NASA

$3,800,000—**Lockheed Aircraft Corp.,** Lockheed Electronics Co., Plainfield, N.J., to provide services for a year at the Manned Spacecraft Center.

$2,226,000—**Case Institute of Technology,** Cleveland, toward the construction of Case Laboratory for Space Engineering Research.

$1,000,000—**University of Rochester,** Space Science Center, Rochester, N.Y., for construction of the $1.5-million laboratory building to house the center's research activities.

$636,000—**General Dynamics Corp.,** Electronics Div., Rochester, N.Y., for three contracts to provide advanced diversity tracking receiver for use with the *Tiros* satellite and to provide other telemetry equipment.

$504,231—**United Aircraft Corp.,** Pratt & Whitney Div., East Hartford, Conn., for brayton cycle turbomachinery roller contract bearings.

$491,500—**Lockheed Aircraft Corp.,** Nuclear Products, Marietta, Ga., for study of effect of irradiation on material at cryogenic temperature.

$235,448—**Firestone Tire and Rubber Co.,** Akron, Ohio, for development and testing of advanced shaped-charged meteoritic simulators.

$170,267—**Aerojet-General Corp.,** Von Karman Center, Azusa, Calif., for improved cryogenic resin/glass filament-wound composites.

$148,260—**Epsco, Inc.,** Westwood, Mass., for solid-state differential amplifiers.

$81,921—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., for design, fabrication and test and delivery of ammonia resisto-jet thrustor systems.

$47,500—**Goodyear Aerospace Corp.,** Akron, Ohio, for a re-entry and recovery system application study.

$26,300—**Ling-Temco-Vought,** Ling Altec Inc., Winchester, Mass., for vibration test system.

$12,200—**Robertson Youngquist Associates,** Washington, D.C., for a planning study for solid core nuclear rocket flight vehicle development program.

Simmonds Precision Products, Inc., Tarrytown, N.Y., to develop a hydrogen detection system and an explosion detection system for use on the *Saturn V* vehicle (amount not disclosed).

INDUSTRY

$745,000—**Mosler Safe Co.,** Hamilton, Ohio, from **The Boeing Co.,** Seattle, for security vault doors used in underground *Minuteman* launch control centers and silo-launchers.

$400,000—**Swedlow Inc.,** Garden Grove, Calif., from **North American Aviation, Inc.,** Rocketdyne Div., McGregor, Tex., for motor case insulative liners for the *Sparrow III* and *Shrike* missiles.

NATIONAL SCIENCE FOUNDATION

$69,228—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., to analyze and evaluate scientific measurements taken during the International Years of the Quiet Sun.

REQUESTS FOR BIDS

GENERAL PROCUREMENTS

Rome Air Development Center
Procurement Division
Attn: EMKS
Griffiss AFB, N.Y. 13442

Rome Air Development Center contemplates the negotiation of a contract with Cornell Aeronautical Laboratory, Inc., for a study of a laser-triggered switch. RFP not available.

Air Force Flight Test Center
Directorate of Procurement
Edwards AFB, Calif.
Attn: FTMKR-2

Negotiations are being conducted with Marquardt Corp. to perform hot firing evaluation of spiral-wound ribbon structures for transpiration/film cooling. This notice does not solicit proposals but is issued for the benefit of prospective subcontractors with appropriate security clearance, who should make direct contact with the above firm for subcontracting opportunities.

Air Force Special Weapons Center
Procurement Directorate
Attn: SWMKB
Kirtland AFB, New Mexico 87117

General Atomic is being contacted for follow-on work for study of radiation effects on dynamic electronic components. No other known organization possesses the unique capabilities and qualified personnel required. This notice is for the benefit of prospective subcontractors with proper security clearance; direct contact should be made with the above company.

Air Force Special Weapons Center
Procurement Directorate
Attn: SWMKB
Kirtland AFB, New Mexico 87117

Follow-on contracts are being negotiated with Ion Physics Corp. and Field Emission Corp. for development of X-ray systems. This notice is for the benefit of prospective subcontractors with proper security clearance; direct contact should be made with the above company.

Office of Naval Research
Washington, D.C. 20360

Negotiations are to be conducted with Vitro Laboratories for further research on the Naval Research Laboratory's research and development program for the fleet ballistic missile. For information only; RFP not available.

Air Force Flight Test Center
Directorate of Procurement
Edwards AFB, Calif.
Attn: FTMKR-2

Negotiations are being conducted with United Aircraft Corp., United Technology Center, to conduct a program to demonstrate the ability of foam ceramics composites to withstand the environments of advanced rocket engines employing high energy propellants. This notice is for the benefit of prospective subcontractors with proper security clearance; direct contact should be made with the above company.

George C. Marshall Space Flight Center
Purchasing Office
Huntsville, Alabama 35812
Attn: D. Hall

RFQ DCN 1-6-30-32507 was issued on a first-come, first-served basis for a magnetic forming technique program. Requests for copies filled only upon written inquiry.

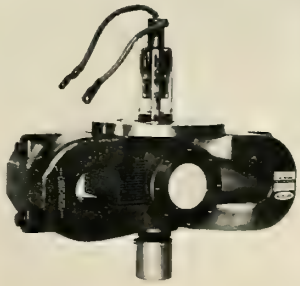
Office of Naval Research
Washington, D.C. 20360

ONR has received an unsolicited proposal from Ball Brothers Research Corp. for refurbishment and retesting of solar pointing controls and telemetry systems and is considering the award of a contract in accord with their proposal.

New Product of the Week: Air-Cooled Magnetron

An air-cooled magnetron delivering pulses of a million watts for C-band radar systems has been introduced by Raytheon Co.'s Microwave and Power Tube Div.

Tunable from 5,665 to 5,715 mc, the QKH1214 magnetron offers more latitude in tracking radar systems than the fixed frequency QK539 for which it is a replacement. Pulse width is 1 μsec. The new mw peak power output is delivered with a 0.001 duty cycle. Anode voltage is 35 kw. Peak anode current is 65 amperes. It weighs 50 lbs. and has a waveguide output.



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Chronetics, Inc. has a dual prescaler accepting input rates in excess of 100mc and with a dynamic range of better than 10:1. The Model 109 dual prescaler consists of two identical, isolated decade prescaler sections in a single case. Using one of the sections, 10-mc counter/scalers may be used at rates to 100mc. If both sections are cascaded, Model 109 will drive a 1-mc counter/scaler with 100-mc inputs.

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A Model 970 transistor analyst, manufactured by B&K Manufacturing Co., permits in-circuit testing of almost any analog, ac- or dc-coupled transistor circuitry.

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AUGUST

Sixth International Electronic Circuit Packaging Symposium, sponsored by Electrical Design News (concurrent with WESCON), San Francisco Hilton Hotel, San Francisco, Aug. 23-24.

Cryogenic Engineering Conference, Rice University, Houston, Aug. 23-26.

Conference on the Exploration of Mars and Venus, sponsored by Virginia Polytechnic Institute, NASA and Air Force Cambridge Research Laboratory, Blacksburg, Va., Aug. 23-27.

1965 Western Electronic Show and Convention (WESCON), San Francisco, Aug. 24-27.

Sixth Biennial Gas Dynamics Symposium, sponsored by American Institute of Aeronautics and Astronautics and Gas Dynamics Laboratory of Northwestern University, Northwestern University, Evanston, Ill., Aug. 25-27.

Annual Conference on Applications of X-ray Analysis sponsored by Denver Research Institute, University of Denver, Albany Hotel, Aug. 25-27.

1965 International Symposium on Antennas and Propagation, sponsored by Institute of Electrical and Electronics Engineers, Sheraton Park Hotel, Washington, D.C., Aug. 30-Sept. 1.

Twelfth National Conference of the Armed Forces Management Assn., Washington Hilton Hotel, Washington, D.C., Aug. 31-Sept. 2.

SEPTEMBER

Second Annual Conference on the Effects of Shock and Vibration on the Human Body, sponsored by University of Denver and the Colorado Chapter of the Institute of Environmental Sciences, University of Denver, Denver, Sept. 1-3.

URSI Symposium on Electromagnetic Wave Theory, sponsored by U.S. National Committee, International Scientific Radio Union (URSI), Technological University of Delft, The Netherlands, Sept. 6-11.

XVI International Astronautical Congress, sponsored by the International Astronautical Federation, Athens, Greece, Sept. 12-18.

Thirteenth Annual Joint Engineering Management Conference, sponsored by American Institute of Aeronautics and Astronautics, Institute of Electrical and Electronics Engineers, American Society of Mechanical Engineers, and others, Roosevelt Hotel, New York City, Sept. 13-14.

Thermophysics Specialist Conference, sponsored by AIAA, U.S. Naval Postgraduate School, Monterey, Calif., Sept. 13-15.

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The Picture Brightens

OPENING OF THE ANNUAL WESCON electronics show in San Francisco this week calls attention to a new optimism pervading the electronics sector of this industry.

A year to eighteen months ago, many of the leaders in the field were frankly downcast about the future. There was much talk of diversification, with dour looks at the balance between commercial and military business.

Today the picture has changed. WESCON itself certainly will reveal no industry slow-down. Upwards of 35,000 visitors are expected to view the wares of more than 1,000 exhibitors during the four-day show. There is a new air of optimism. Companies doing $60 million annually in sales talk of crossing the $100-million line in the not too distant future. Yet, early in 1964, nothing but lugubrious expressions could be found in the paneled front offices of these same firms.

What has brought about the change?

For one thing, that brief, unwarranted recession in the industry made many electronics companies take stock of the exposed position in which they had been living almost solely off the nation's defense and space dollars. The period following the Korean War had been one of unparallelled growth. The National Aeronautics and Space Administration budget was expanding, and with President Kennedy's initiation of the manned lunar landing program, it really took off. And, as everyone knew, a space vehicle was 70% electronics.

At the same time, all three military services were investing heavily in missiles, with their accompanying vast array of tracking gear, guidance and control systems and telemetry. All of this increased the need for data-handling equipment many-fold.

Why worry about the invasion of the commercial field by low-cost Japanese equipment? Certainly it's something to talk about, but those foreigners can't get into the big money, into those lush Government contracts. Why worry if 90% of the firm's business is with the Government? There'll always be a need for weapons and the space dollar stretches as endlessly as the universe itself. No wonder that talk of a leveling off in the NASA budget and a somewhat more conservative approach to defense spending hit some electronics companies, more than others, like a clap of doom. Their vulnerable position was painfully evident.

As a result, much of the distress was psychological, with the gloom much deeper than justified by actual events. The effect of this sensitivity was evident in a plunging market.

Despite the soul-searching experience of that period, today's optimism is partly on the same basis. Expansion of the war in Viet-Nam has given promise of an improved market for electronic military equipment. The effect of this has been evident even before new money for the purpose has begun flowing to industry, or has been appropriated by Congress. One major firm, analyzing the upturn, finds that it has occurred even before receipt of a single order traceable to the Viet-Nam war. Psychology works both ways.

A case can be made, however, that the new strength in the electronics sector is based upon more than the appearance of a firmer military market. That brief shiver that ran through the industry did indeed lead many firms toward diversification and onto a sounder business footing in regard to their ratio of Government to commercial sales. In some cases this was achieved by acquisition and in others by increased management attention to the potential of technology developed initially under Government contracts.

The talents of the electronics firms in power, heat and wave generation, application, sensing and control can be applied to many uses outside the missile and space field. On-line processing activities in the food, chemical and petroleum fields offer one area in which this advanced technology can be put to work in the civilian economy. These major industries offer potential dollar returns comparable to those obtainable under Government contracts. They also are bulk industries in which the saving of even a few cents through employment of improved technology can mean substantial profits.

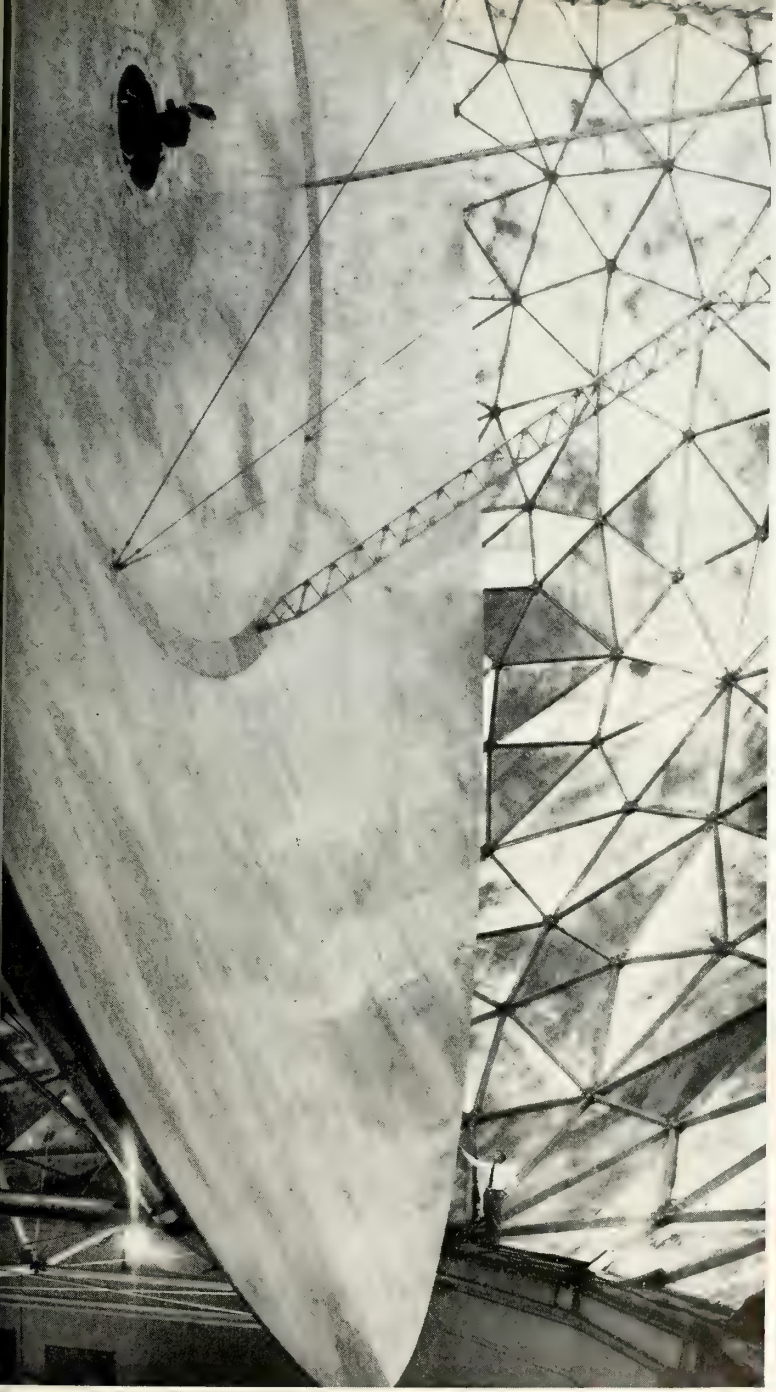
THIS IS BUT ONE EXAMPLE of the new uses that can be found for familiar technology. It is the successful search for such uses that is one factor behind the strengthened electronics market. If the brief recession served to spur this, then it may have done more good than harm. For there are new areas in the Government, as well as the commercial, market still worth exploring.

The war in Viet-Nam has brought a demand for application of advanced technology to familiar tactical problems there and elsewhere in the military field. Here are a few outlined by the Dept. of Defense:

- There is a need for compact equipment that will enable small military units to locate themselves accurately and then convey this information quickly to a central command post.
- Devices that permit more accurate navigation to known fixed locations are required.
- Better methods of terminal guidance to ground targets are desired.
- Improved methods are sought for the early detection of low-flying aircraft.
- Devices for identifying friendly forces and marking enemy forces are urgently needed.

These are only some of the requirements of limited warfare to which missile and space electronics technology can be applied. Together with applications in the commercial field, they offer new market opportunities which can lead to a more diversified, broader-based business. Any company that ignores this has lost a valuable lesson of the past eighteen months.

William J. Coughlin



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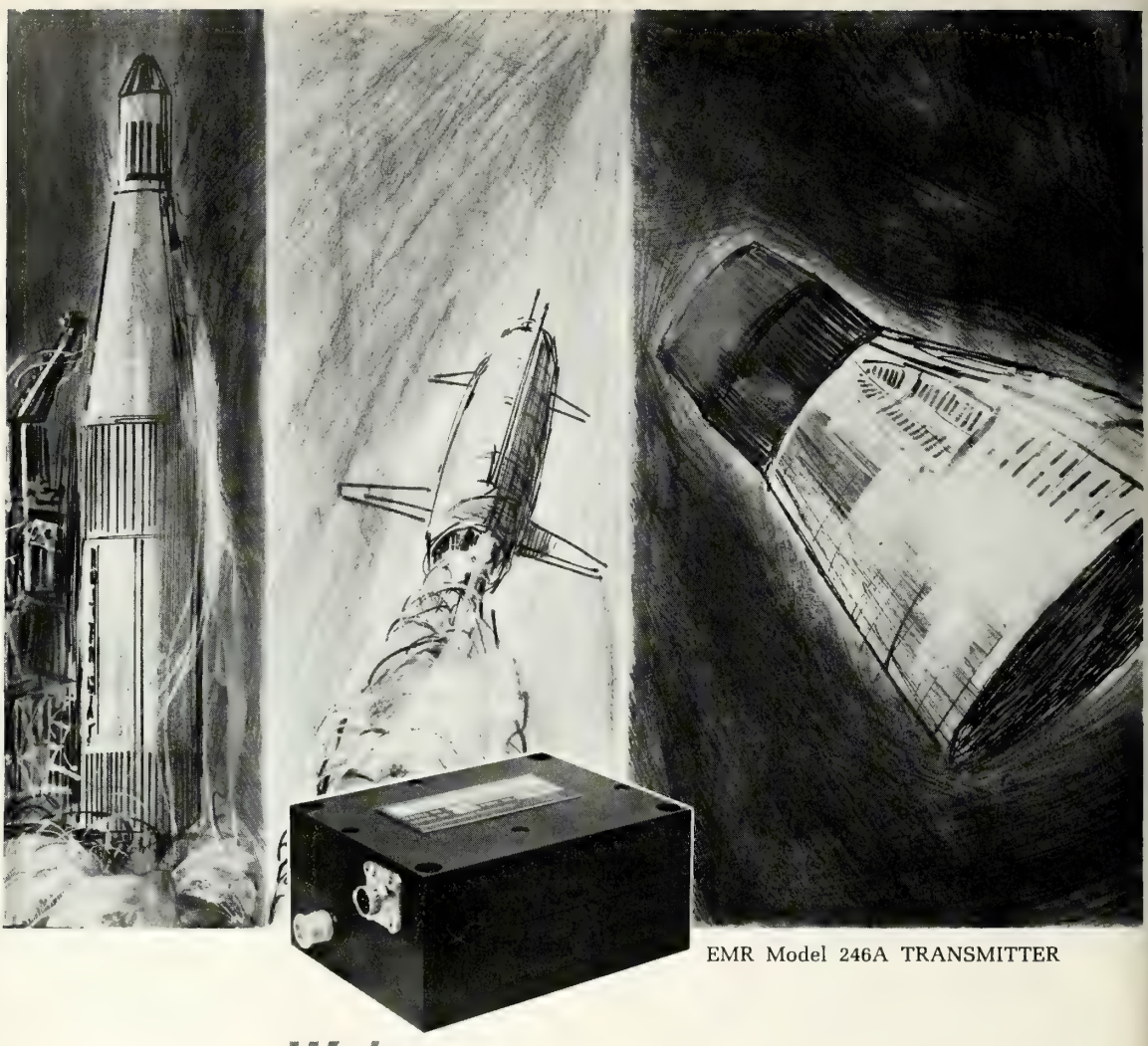

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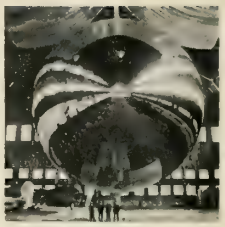
THE COVER



G. T. Schjeldahl Co.'s tautly inflated Pageos satellite resembles giant ball bearing-like mirror in hangar at Lakehurst, N.J. The plastic passive geodetic satellite is spherically accurate to ½ of 1%. Pageos will be launched and inflated in orbit next year. *See p. 12.*

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letters

Informing the Public

To the Editor:

I was much interested in Donald L. Zylstra's article, "Public Ignorant of A-ICBM Situation" (M/R, Aug. 16, p. 32). My interest was increased because of receiving in the same mail the August issue of *Nuclear News*, containing "The Atom, The Public and You," by William E. Shoupp, retiring president of the American Nuclear Society. Mr. Zylstra's summary of the TEMPO report tells a story similar to Mr. Shoupp's timely speech.

Messsrs. Zylstra and Shoupp have called attention to a very important matter about which something should be done soon. Atomic energy and missiles and rockets are likely to have a dominating effect on our lives and nothing is more important than that people should know something about them. Industries in both fields should do what they can to change the situation.

The creation of an informed and understanding public will not be easy. Simple but sound expositions in newspapers and on TV programs probably offer the most effective way if one can get these media to present the material. Some facts might be presented under the guise of advertising. Magazine articles might help.

I must admit not being able to present any particularly effective ideas, but I believe that the education of the public is essential to the welfare of the nation.

B. A. Rogers
College Station, Tex.

P.S. Many of your editorials are excellent.

O.N.E.R.A. Coverage

To the Editor:

Coming back from holidays I have had the pleasure of finding several recent issues of MISSILES AND ROCKETS containing items related to O.N.E.R.A.:

a) *Magnetic suspension*—It has been pleasant indeed to find a photograph of ours on the cover of July 19 issue. The caption on page 5 is good, but it could be said that this equipment is an in-house development.

In the article on page 12 you mentioned the American work that has been done on that kind of apparatus, and Mr. Covert, of M.I.T., answered on that point in a letter published in your Aug. 9 issue; your answer to him is again very nice for O.N.E.R.A.

In fact we know very well the M.I.T. and the A.E.D.C. installations, as American engineers came here some years ago to see our work before building their own equipments. We know that some of these have been extended to measure lift at incidence, which our own cannot do. On the other hand we believe we are the only ones to have used that kind of suspension up to Mach 7; and in doing so we had enough trouble to consider this achievement worthy of a news release.

b) *Missile/Space Encyclopedia*—We thank you for publishing details furnished on O.N.E.R.A. projects. We have noticed with interest the fact that you mentioned also the first launching of *Tacite*, which took place on June 15.

The beautiful photograph of our *Lex*, page 132, has been highly appreciated.

c) *New Lex Launchings*—On page 21 of the Aug. 16 issue you published the photograph of *Lex* in flight, together with a detailed caption. I am sorry to have written a rather cumbersome sentence, which you reproduced fully, but if it has amused your readers it is all right with me. In fact it is translated French—and I did not write the French. I had expressed the same idea, in much fewer words, in the caption that appeared on page 132 of your July 26 issue.

Thank you again for your attention. We hope that your and your readers will continue to be interested in our activities.

Max Salmon
Head, External Relations
Office National D'Etudes
et de Recherches Aerospatiales
(O.N.E.R.A.)
Chatillon, France

Box Score Perils

To the Editor:

Perhaps we are allowing ourselves to be somewhat carried away in these stirring, post-*GT-5* launch days, by the temptation to conclude from the cumulative "box score" on manned spaceflight (U.S. vs. USSR) that we are opening up a new "space gap."

While conceding that the U.S. has indeed orbited many more satellites of one kind or another than have the Russians, and that we appear to be ahead in applications and unmanned exploration, I question whether this doesn't really prove only that the U.S. has a richer economy (scarcely a new development)—not that we necessarily have superior technology.

As for man-hours in orbit, granting that we have the advantage for the moment, I still hope that no one concerned will be too astonished if in the near future the Soviets accomplish something that will knock the box scores skitterwise.

Dale Morrison
Chicago

Reprints of M/R Index

Reprints of the editorial index of articles appearing in MISSILES AND ROCKETS during the first six months of 1965 are available at no cost from:

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The Countdown

WASHINGTON

Gemini Booster Recovery Is a Puzzler

NASA still has not explained how a portion of the *Titan II* booster for *Gemini* 5 was able to re-enter the Earth's atmosphere without burning up. Martin Co. engineers who designed the booster have asked that the section of the first stage which was recovered by the USS Du Pont be returned to the firm's Baltimore plant for analysis and tests. It's reported that the section is 10 ft. in diameter and 23½ ft. long. Rate gyro packages and other pieces of equipment appeared to be in place and intact.

Gemini 7 Graduates to Flight Simulation

Phase I acceptance review of the *Gemini 7* spacecraft took place Aug. 24 at McDonnell Aircraft Corp. in St. Louis. NASA officials were pleased with the review and did not request that any changes be made in the spacecraft or its systems. It will now move into simulated flight tests.

Atlas-Agena Passes Countdown Test

Manned Spacecraft Center officials were gratified by the simultaneous countdown of an *Atlas-Agena* during the wet-mock test prior to the *GT-5* launch. Ken Kleinknecht, deputy director of the *Gemini* program, told M/R that "as far as I know, it was a successful countdown; we would have launched during the required launch window for a rendezvous mission." One more wet-mock test is planned with an *Atlas D-Agena* prior to the simultaneous countdown and launch for *GT-6*.

GT-7 Spacesuit May Come Off Altogether

Only qualification of a new lightweight, less bulky spacesuit stands between the *Gemini 7* astronauts and their desire to have a shirt-sleeve environment during their 14-day flight. Manned Spacecraft Center's Crew Systems Div. and David Clark Co. are working on the qualification program. The suit, the upper part of which will resemble a hood or parka rather than the current space helmet, may even be removed completely by the astronauts.

DOD To Initiate New Cryogenic Engine Work

An engine demonstration program will be begun in FY 1966 to provide design data for future development of a high-performance cryogenic liquid rocket engine based on a modular approach. Overall aim is to get a 50% payload improvement over current cryogenic technology. DDR&E's Dr. Harold Brown told the Senate Space Committee the program would be closely coordinated with NASA to avoid unwarranted duplication of space agency developments. NASA at present has no definite engine of this general description in mind other than the ill-fated M-1.

Another Saturn V Uprating Idea Emerges

NASA long-range planners are considering the possibility of uprating the *Saturn V* launch vehicle by adapting the stages to produce an all-high-energy system. This would be beyond the development and operational use of a new high-energy upper stage applicable to current major booster systems for solar-system exploration. Homer E. Newell, Associate Administrator for Space Sciences and Applications, told the Senate Space Committee that such high-velocity vehicles would satisfy unique needs of his office that are not adequately met by current *Apollo* and military launch systems.

Plans for Hand-me-down Agena Deferred

Astronauts Frank Borman and James Lovell will attempt to stay with the second stage of their *Titan II* booster after they get into orbit in *Gemini 7* in early 1966. Plans to rendezvous with the *Gemini 6 Agena* target vehicle, discussed by astronauts earlier, have been temporarily postponed. The plan called for maneuvering the *Agena* into a very large orbit after the *Gemini 6* rendezvous and docking exercise so that it would naturally decay to *Gemini 7* altitude about two months later.

Webb Seeks Two-Year Voyager Speed-Up

First *Voyager* landing on Mars will be made in 1973, unless the present budget level is allowed to go up, NASA Administrator James E. Webb has told the Senate Space Committee. He said that he would prefer a decision to shoot for a 1969 flyby and a 1971 landing. Funding for FY 1967 was estimated at about four times that in FY '66—presumably something over $200 million.

STAFF Flight Due in Two Months

Next flight in the STAFF (Stellar Acquisition Flight Feasibility) program is expected around Nov. 1. Fourth in the series, the launching of the General Precision Aerospace stellar-inertial guidance platform aboard a *Polaris* test vehicle will mark the first attempt to lock onto two stars during the daylight flight. First it will attempt to lock onto the star Polaris, then it will seek to acquire one of 10 other potential stellar targets. One more flight in the STAFF program is anticipated, probably in December or January. Its future is uncertain, however, and is tied intimately to the unclear future of mobile ballistic missiles in the U.S. inventory.

INDUSTRY

Thiokol 260-in. Program Still Kicking

Thiokol Chemical Corp. has some hopes of continuing its 260-in. solid rocket motor program, in spite of NASA's cancellation of its contract because of ruptures in two cases built by a subcontractor. One possibility, should NASA decide to go ahead with the program, is the use of one or both of the Aerojet 260-in. cases after they are fired, in the same manner in which Lockheed reused a fired 156-in. Thiokol case.

Philco Working on Color TV Display

Philco Corp. has been awarded two NASA contracts to develop an all-electronic television display system with color capability. System will consist of a digital two-color TV display converter and a color TV monitor that will display the output of the d-c TV converter. The display converter will be developed under a $70,000 contract, the monitor under a $78,000 award.

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Laser R&D Spending Soars

SAN FRANCISCO—Total U.S. laser research and development will approach the $100 million mark this year. Total expenditure by the government and by industry will steadily increase to about a half billion dollars a year by the mid-1970's, according to estimates by W. H. Huntley, Jr., of Stanford University's Electronics Laboratories.

Speaking before the Aug. 24-27 1965 Western Electronic Show and Convention (WESCON) at the Cow Palace here, Huntley said that in 1964 and early 1965 "A crossover point was reached and direct applications R&D now appear to exceed in dollars the effort on basic research." Huntley also noted that for the past two or three years, government-sponsored R&D has greatly overshadowed private investment in this area, and that "government laboratory activity has undergone great expansion."

In 1964, Huntley estimated that government spending on lasers was divided among the major agencies in the following ratio: Air Force—60%, Army—20%, Navy—9%, NASA—8%, and 3% scattered among other groups. Increases in 1965 in NASA laser spending and decreases in portions of military R&D have now altered these figures, Huntley estimated, to a point where NASA is probably spending more now than either the Army or Navy.

Based upon open literature figures, which obviously do not include any of the high-power military laser programs, Huntley estimated that maximum available single-pulse laser energy levels are now on the order of 6,000 joules, with maximum single-pulse laser power output approaching 10 gigawatts.

Huntley noted that the ceiling on peak power output has been held fairly constant for the past one to two years because of breakdown of materials within the laser.

For pulsed gas lasers, Huntley said that powers of 100,000 watts are now possible, but that materials breakdown problems appear to be limiting the cw gas lasers to powers of about 18w.

Repeating last year's heavy emphasis on semiconductor integrated circuits, manufacturers presented broadened device lines but tended to stress new materials and packaging techniques plus improved performance characteristics.

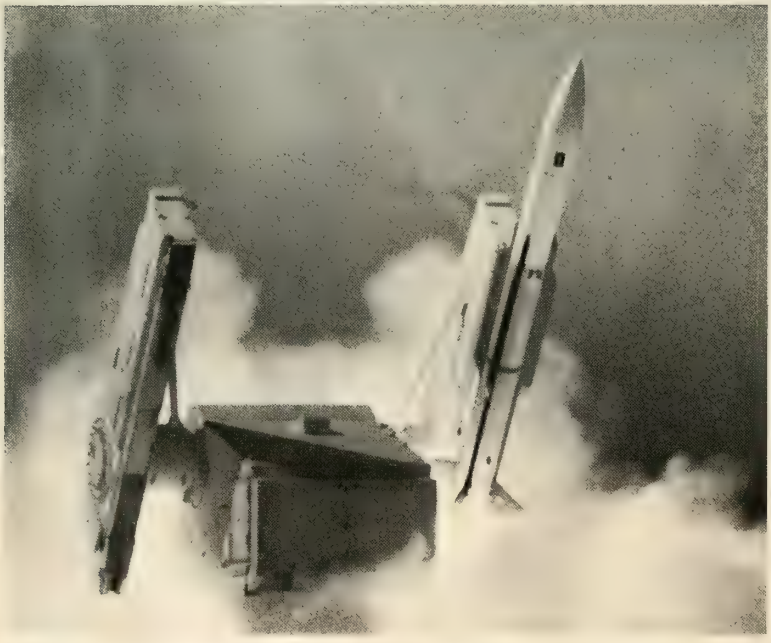
An estimated 35,000 registered for the four-day event. The Cow Palace was jammed with nearly 1,100 displays, and a military/space deemphasis was evident throughout the exhibits. If any single new trend was in evidence it was an increase in oceanographic hardware.

The only two military sponsored displays at the meeting—those of the Naval Electronics Laboratory and Naval Ordnance Test Station—both featured undersea systems.

However, for those aerospace systems engineers seeking some new and potentially useful equipments, there were roughly a half dozen new developments displayed for the first time that were attracting attention.

For example, American Electronic Laboratories, Inc., of Lansdale, Pa., displayed a small new cavity backed spiral antenna designed to cover bandwidths in excess of 10:1, which appears to be easily flush-mounted aboard a variety of vehicles. AEL says the circularly polarized antennas, which cover a frequency range from 400mc to 10gc in two versions, are especially suited for ECM and airborne surveillance roles.

Watkins-Johnson Co. engineers displayed a new satellite telemetry package developed as an advanced R&D effort under NASA contract. The small, integrated traveling-wave-tube/power supply package operates at S-band and includes the firm's new WJ-274-2 TWT, which puts out 20w cw and reportedly operates at an efficiency in excess of 40%. The NASA support centered on the development of the high-efficiency TWT's.



Navy Standard Missile Configuration Fired

A MISSILE configuration similar to the probable ultimate design of the Navy's standard air defense missile is shown in first-released photo of the test flight in which Aerojet-General Corp.'s new propulsion system was used. The standard missile will be similar to the now-operational Tartar, but will have 50% more range. It will replace the Tartar, Talos and Terrier surface-to-air weapons. The boost-to-sustainer thrust of the Aerojet-General system is 10 to 1, and the total impulse of the new solid propellant system is 1.5 times greater than that of the Tartar. The Aerojet system is one of the candidates for the new missile.

Shots of the Week

Astronauts L. Gordon Cooper and Charles Conrad were launched into an eight-day orbital mission at 10:00 a.m. EDT Aug. 21 aboard the *Gemini 5* spacecraft. (See page 16).

- Two new Soviet satellites, *Cosmos 78* and *79* are now in orbit. *Cosmos 78* was launched Aug. 14 and has

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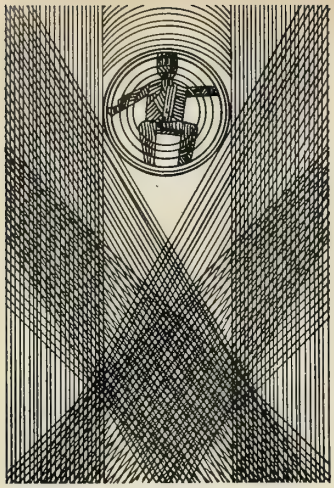

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an apogee of 329 km and a perigee of 209 km. Its inclination is 69 degrees.

- *Cosmos 79*, launched Aug. 25, has an apogee of 222 mi. and a perigee of 130 mi. Its inclination is 64.9 degrees.
- Two *Minutemen* ICBM's were fired from Vandenberg Air Force Base down the Western Test Range —one on Aug. 24 and the second Aug. 25. Both were observed, photographed and tracked visually and with heat-seeking instruments aboard the *Gemini 5* spacecraft by Astronauts Cooper and Conrad.
- An *Orbiting Solar Observatory* was launched from Cape Kennedy Aug. 25 aboard a three-stage *Delta* vehicle. The 620-lb. satellite is designed by Ball Brothers, Inc. for NASA to check electromagnetic radiations from the Sun. *OSO-C* was to hit an orbit about 345 mi. high but NASA officials indicated the *Delta's* X-258 solid third stage ignited about 5 seconds too soon due to malfunction of the delay igniter squib. Scheduled acquisition of the satellite by the Johannesburg, S.A., station at T+30 min. never occurred. *OSO-C* is presumed lost.
- Two *Athena* vehicles were fired Aug. 20 from Green River, Utah, to White Sands Missile Range, N.M., but one of the flights was terminated because of a computer malfunction.
- NASA Pilot Milton Thompson took *X-15* No. 1 to 214,000 ft. and a speed of 3,511 mph in the 144th flight of the rocket plane Aug. 25. Purpose of the flight was to provide navigational reference points for future *Apollo* astronauts.
- An often-scrubbed *Minuteman II* launch took place from Cape Kennedy Aug. 23. The ICBM, which was also to have been tracked by the *Gemini 5* crew, made a successful 4,000-mi. flight—its ninth in as many launches—down the Eastern Test Range. The *Gemini 5* was not in a position to view the firing.

Crawler Work Suspended

All work has been suspended on two crawler-transporters built by the Marion Power Shovel Co. for NASA. The huge units are intended to transport the mobile launcher and the entire *Saturn V/Apollo* vehicle to its launch site.

With changes and modifications, the total cost of the two tracked vehicles—each designed to carry a combined 12-million-lb. load—will exceed $12 million.

Some or all of the 176 track support roller bearings failed during a routine trial run of the crawler carrying a mobile launcher. The first major flaws detected were in the 16-jack hydraulic leveling system. A second problem in the electronic circuitry was uncovered later and no solution has yet been found (M/R, May 10, p. 17).

The original contract called for the first crawler to be delivered and operational in 20 months, with the second crawler due some four months later. To date, a year after the due date for the first delivery, neither has been accepted by NASA.

SNAP-50 Funds Restored

The Senate Appropriations Committee has added $2 million to the SNAP-50 program, raising funding for the program to $12 million for FY '66. The Senate group concurred with the House in deleting $6 million from the SNAP-10A program.

Total SNAP recommendations of $52.5 million by the House and $54.5 million by the Senate are considerably under the $70.5-million original request by the Atomic Energy Commission. The Committee action Aug. 19 was approved by the full Senate Aug. 24.

Schjeldahl Tests Pageos

The first of six inflatable 100-ft.-dia. satellites designed for use in the national geodetic satellite program is under test in the Navy's huge blimp hangar at Lakehurst, N.J.

The spheres are constructed of metallized Mylar by G. T. Schjeldahl Co., and are almost identical to the *Echo I* satellites. The six satellites are being built under an $804,000 contract from NASA's Langley Research Center.

One of the satellites will be launched early in 1966 into a near-polar orbit of 2,300 mi. As the sphere reflects sunlight, ground cameras will photograph it against a star background in an effort to gather data for precisely locating any point on Earth.

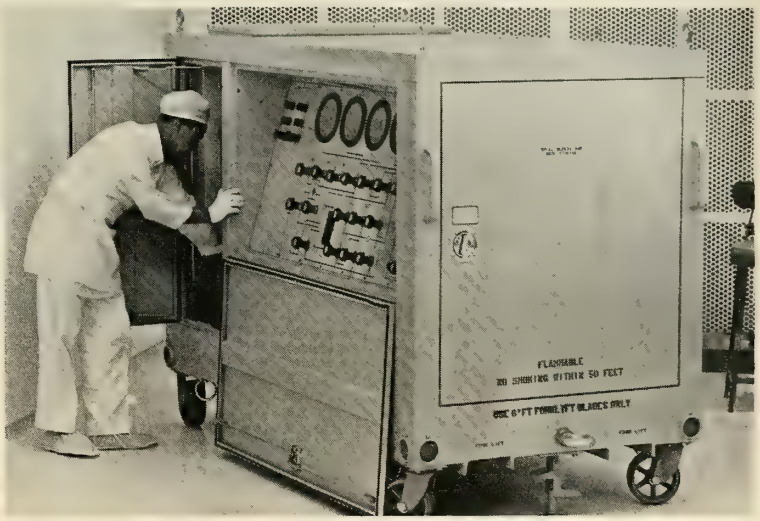
The *Passive Geodetic Satellite—Pageos*—should remain in orbit for five years.

Aerojet Gets Navy Contract

Aerojet-General Corp. will manufacture Mark 46 torpedos and related equipment under a Navy BuWeps contract totalling $60,698,094. Work will be performed at the firm's Azusa, Calif., complex.

The contract, awarded last week, will result in the hiring of about 200 production and technical personnel at Aerojet, with about 100 to be hired within the next 60 days.

If you need a compact liquid propellant servicing system for a spacecraft, service module or space lab, and you need it in a hurry—call Garrett.

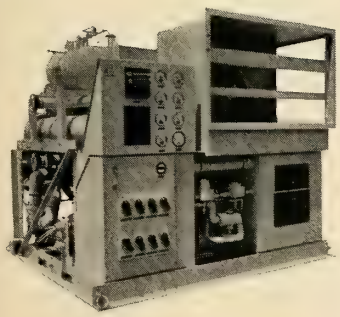


For example, look at the Surveyor spacecraft propellant fill and conditioning system we built for Hughes under contract to the Jet Propulsion Laboratory for NASA.

Not only does it have some exceptional design features, but we completed it weeks ahead of time on a tight delivery schedule.

The system is completely mobile and self-contained. It cleans, flushes and purges the spacecraft's vernier propulsion system, checks out the pneumatic components, and fills the tankage with monomethylhydrazine hydrate fuel and nitrogen tetroxide oxidizer.

With these toxic propellants we



need a safe, effective vapor disposal system. So, in keeping with the compactness of the system, we designed small, efficient units and put them inside the carts.

Without any external propellant disposal facilities whatsoever, we keep the toxic vapor level to less than 10 parts per million, which makes it completely safe for operating personnel.

These are the units in the system:

The Control Console checks the pneumatic components of the spacecraft propellant system, and supplies the operating pressure for the servicing and purge carts. It has 3000 and 6000 psig nitrogen channels, and 3000, 6000 and four 800 psig helium channels.

Servicing Carts store propellants, evacuate the spacecraft propellant system, load and offload propellants. Vapor disposal systems are self-contained.

Purge Carts (shown above) flush the spacecraft propellant system with solvent, purge with nitrogen, then evacuate and dry the system. Carts have self-contained vapor disposal systems.

We also make Propellant Thermal Conditioning Systems. The one shown at left is for the propulsion system on the Apollo spacecraft service module.

This compact system provides temperature control for batch-stored propellants, and propellants that are being transferred to the spacecraft.

So, as we said, if you need compact liquid propellant servicing systems for spacecraft, space labs or service modules, or other missile, space and avionics AGE equipment, come to Garrett.

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Douglas Wins Epochal MOL Contract

President Johnson officially announces long-deferred decision to proceed with $1.5-billion military program; GE to plan experiments

by Donald L. Zylstra

DOUGLAS AIRCRAFT CO. has been chosen to develop and build the Air Force *Manned Orbiting Laboratory (MOL)*, a program expected to cost $1.5 billion. In making the announcement at an Aug. 25 White House press conference, President Lyndon B. Johnson said General Electric Co. has been chosen to plan and develop the space experiments to be orbited in the laboratory.

The $1.5-billion program calls for "several unmanned *MOL* launchings, to be followed by a total of five flights by two-man crews"—indicating that a minimum of six or seven launches are currently planned.

A defense official briefing Pentagon reporters suggested that the unmanned launches would be limited to "one or two"—two unmanned launches coinciding with the number of early *MOL* launches now scheduled in the series of 12 research and development tests of the Martin *Titan III-C* launch vehicle which will boost *MOL* into orbit. The *Titan III-C* schedule now reserves launches 11 and 12 tentatively "for tests involving early vehicles in the *MOL* program."

Pentagon officials placed the initial unmanned launch of a fully-equipped *MOL* in 1968, indicating that unmanned flights to "test launching, recovery and other basic parts of the system" are due to begin late next year or early 1967. First manned flights would come late in 1968, according to present estimates.

On Dec. 10, 1963, in making the first announcement of the Pentagon proposal to develop *MOL*, Secretary of Defense Robert S. McNamara estimated the first launch of the converted *Gemini-X* capsule associated with the system would be "in the first half of 1966 and manned in the second half of 1966." He went on to say that the unmanned version of the complete *Gemini-X*/canister *MOL* system would probably come in "late 1967," with the manned *MOL* being orbited for the first time in the first half of 1968.

Thus the prediction last week of a first manned flight "in 1968" seems to correspond roughly with McNamara's initial estimates, but could indicate that as much as six or eight months have been lost in the prolonged initial studies of the *MOL* concept. DOD officials carefully avoided admitting any such delay.

A spokesman stoutly defended the long preparatory studies, asserting "we may well have gained several years" rather than lost time, by careful consideration of all the factors involved in the *MOL* concept.

• **Canister lengthened**—When adapted to the *Titan III-C* booster and poised on the launch pad, the *MOL* vehicle will be about 153 ft. tall. From the top of *Titan III-C's* Transtage, to the top of the *Gemini-X* capsule, the *Gemini*/canister payload will measure 54 ft. Originally 25 ft., the canister design proposed by Douglas now measures 41 ft. long by 10 ft. in diameter.

About half this length will be used as a compartment with life-support systems providing a shirt-sleeve environment for *MOL's* two-man crew; the unpressurized remainder will be given over to instrumentation and power supply.

Entry to the canister section from the attached *Gemini* capsule in which the crew will ride into orbit will be provided through a hatch cut in the *Gemini* heat shield. Present concept calls for the two-man crew to remain in the shirt-sleeve environment of the laboratory section during the entire 30-day orbital period, keeping the capsule section in a standby condition, poised for the return to Earth at the end of a month in space, or earlier if necessary.

The pressurized life-support portion of the canister will have a capacity of 1,000 to 1,200 cu. ft. Although this area will accommodate limited instrumentation and its two-man crew, it will afford 400 cu. ft. of unencumbered space for each man, as a working and living area. Total payload weight of the *Gemini*/canister package will be 25,000 lbs.

Two types of atmospheres are still under consideration for the pressurized canister section. One would be the basic nitrogen-oxygen combination found in the Earth's atmosphere and the other a helium-oxygen mixture.

• **Apollo undersold**—Decision in favor of the *Gemini X* capsule rather than some version of the *Apollo* three-man capsule for use with the *MOL* system was largely dictated by cost considerations, DOD spokesmen said. "*Apollo* has capabilities beyond what we need," an official noted. He added that *MOL* will probably use many concepts, components and subsystems developed in the *Apollo* program, but not the capsule itself.

Operating systems being adapted for *MOL* include packages for navigation, life support and power. DDR&E Director Harold Brown, testifying last week before the Senate Space Committee, indicated that plans call for the use of fuel cells aboard. But DOD officials in a press briefing on *MOL* hedged by saying that, while there would obviously be an on-board power source, the decision to use fuel cells has not yet been made.

Brown indicated the possibility that thermoelectric radioisotope units now under development by the Atomic Energy Commission may be tested and available in time for use in *MOL*.

Re-entry from orbit will be accomplished by landings on water using the same techniques now in use for NASA *Gemini* missions. However, *MOL* requirements will permit certain reductions in capsule weight, the *Gemini-X* version being adapted for the orbiting laboratory weighing approximately 6,000 lbs.

• **Vandenberg too**—*MOL* will be launched from both Cape Kennedy and from Vandenberg AFB on the Pacific Coast. A defense official noted that a *Titan-X* pad is already planned for Vandenberg. Additional facilities for *Titan III-C* launchings would be required for the Western Test Range site.

Control facilities of the Eastern and Western Test Ranges would be used to launch, track and control *MOL*, a defense spokesman said, apparently eliminating the possibility that NASA's Mission Control Center at Houston might figure in the *MOL* effort.

Astronauts for the *MOL* program will all be graduates of the Air Force Aerospace Research Pilot's School at Edwards AFB, Calif. *MOL* crews will wear pressurized spacesuits in the *Gemini* capsule during launch into orbit and on re-entry, but will remove them during their extended stay in the laboratory canister.

Negotiations for purchase of *Gemini* capsules adapted for *MOL* are now under way. One recovered *Gemini* will be acquired directly from NASA for early unmanned tests, and negotiations with NASA and McDonnell will determine

whether the other capsules will be purchased through NASA or directly from McDonnell.

Although recovered capsules may be adapted and used if feasible, the all-up qualification test on an unmanned flight and all manned flights will incorporate capsules built specifically for the *MOL* system. Manned flights will all be launched by operational *Titan III-C* vehicles, following the current 12-flight test series.

● **Assignments**—Experiments being prepared for *MOL* orbital flight will investigate all space phenomena that show promise of contributing to military needs. Major experiments in the "P" series now total about 20 and involve tests of man's ability to make visual observations, conduct surveillance, investigate infrared phenomena, radio and radar signal propagation and background effects.

Extravehicular capabilities will be studied—particularly as they relate to man's ability to assemble structures such as radar antennas in space. Such structures might be as large as 100 ft. across, maybe several times larger. Maintenance and repair functions will be studied in other assignments.

For participation in the *MOL* program in relation to its ocean surveillance mission, and to assist in preparing proposed ASW experiments, the Navy has established an office at Space Systems Division. The Army has also been invited to contribute to the effort but has not yet entered any suggestions.

Intercept and identification functions are of major concern in the *MOL* program, with obvious military benefits. But defense officials made a point of emphasizing that no weapons will be carried in orbit, since *MOL* is being developed strictly as a laboratory mainly to determine man's ability to perform missions or functions with ultimate military value.

MOL may be orbited at altitudes considerably higher than those recorded in *Gemini* flights to date because of the 30-day mission, officials said. Earlier indications from technical personnel have estimated that orbits may reach 350 n. mi.

Both rendezvous and ferry capabilities are being designed into the *MOL* system. But neither capacity will be used in the program as now planned, unless emergencies or additional misson requirements make them necessary.

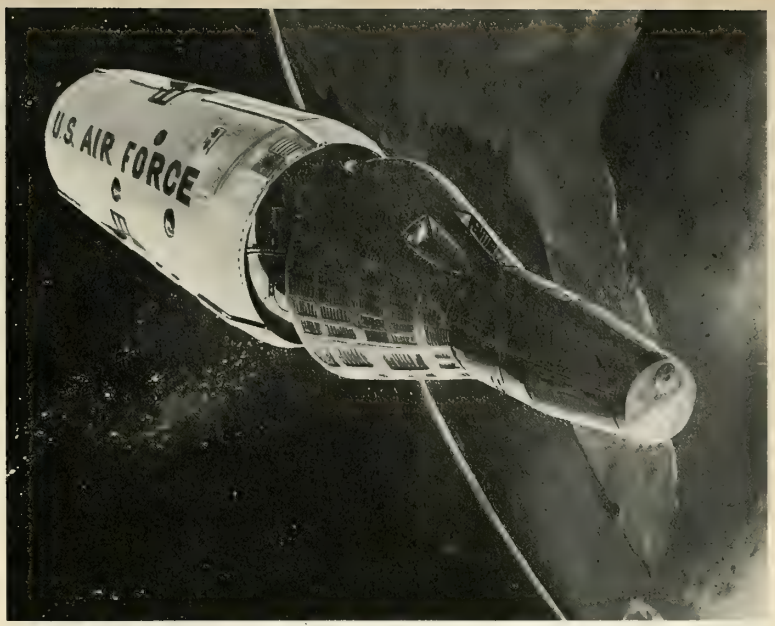
● **Aluminum weighed**—Precise requirements for canister materials and construction haven't been revealed but a DOD spokesman indicated that its outer skin could be aluminum, presumably because present plans do not call for its re-entry or recovery.

No detailed breakdown of the $1.5 billion program cost is available, but this figure includes the price of the *MOL* boosters, officials said.

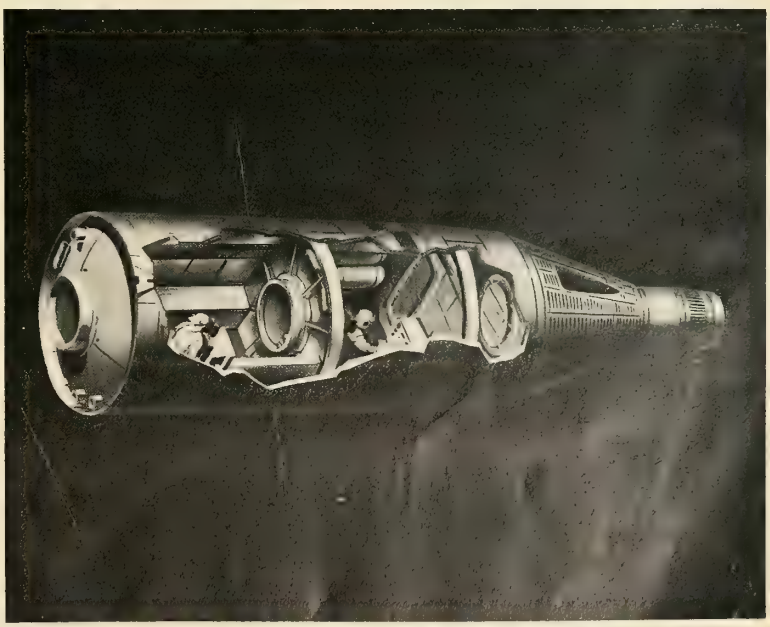
Like the *Gemini* capsule, the *MOL* vehicle will have limited capability to alter its orbits.

Using the *Titan III-C* Transtage (not a part of the final orbiting package), *MOL* can be inserted into orbits with a wide range of inclination. From Vandenberg, inclinations from 65 degrees to 90 degrees would be possible, with equatorial orbits attainable in a Cape Kennedy launch.

Thirty million dollars has been spent on the program to date, and $150 million is in the FY '66 budget. ■



AIR FORCE ARTIST'S CONCEPTION of Manned Orbiting Laboratory attached to modified Gemini spacecraft. Douglas canister and McDonnell spacecraft will be put into orbit by Martin Titan III-C booster. GE will plan experiments.



CUTAWAY VIEW, also by Air Force artist, indicates preliminary thinking as to crew stations and storage areas. Original concept called for canister to be 26 ft. long, but plans now call for 41-ft. length. Five two-man flights are now envisioned.

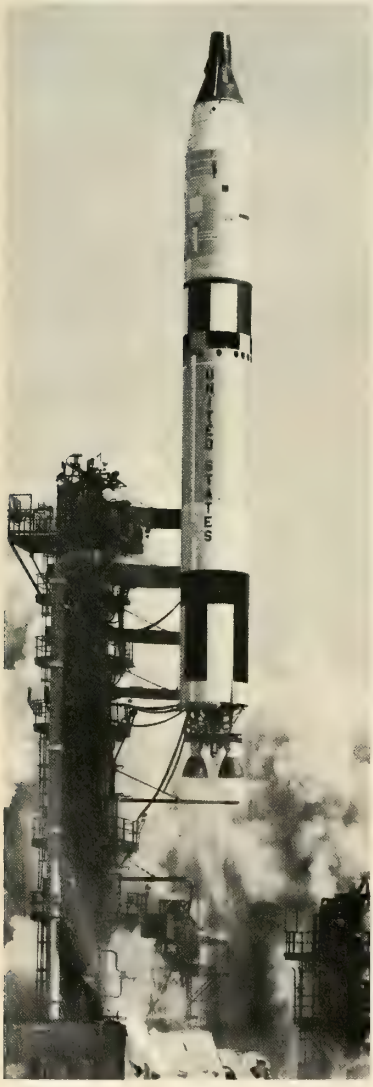
GT-5 Proves U.S. Rendezvous Ability

Longest manned spaceflight also demonstrates military value of orbital manned vehicles; fuel cell, hit earlier by pressure drop, exceeds expectations

by Hal Taylor

HOUSTON—NASA's *Gemini 5* spacecraft has snatched away from the Soviet Union the record for the longest manned spaceflight and given this country a strong claim to world space leadership.

It also cleared the decks for *Gemini-Titan 6*, scheduled for late October, and the planned 14-day *GT-7* mission, which could be launched as early as late December.



GEMINI 5 lifts off from Cape Kennedy in perfect launch on Aug. 21 to begin longest manned spaceflight yet.

The world's longest manned spaceflight, with Command Pilot L. Gordon Cooper and Pilot Charles Conrad at the controls, also proves that:

- The U.S. has developed the technology necessary to rendezvous and dock with an orbiting object in space.
- The oxygen-hydrogen fuel cell is a reliable and far more flexible power plant than U.S. space officials had expected.
- Man can play an important military role in space, including surveillance of missile launches, the identification of ground-based targets and the photographing of objects in space and on the ground.

Gemini 5 began auspiciously on Aug. 21 with a perfect launch by its *Titan II* booster. The Martin Co.-developed launch vehicle blasted the 7,000-lb. McDonnell Aircraft Corp. spacecraft off the pad at Cape Kennedy exactly on schedule, at 10 a.m. EDT, into an orbit ranging from a perigee of 100.6 statute mi. to an apogee of 217.3 statute mi.

The booster's almost flawless performance is illustrated by the closeness to the planned orbit of a perigee of 100 mi. and apogee of 216 miles.

- **Trouble threatens**—Extreme optimism that the planned eight-day mission could be completed successfully was generated by the perfect launch. This suddenly soured when both the astronaut crew and ground tracking stations reported a sudden and drastic drop in pressure in the oxygen tanks feeding the gas into the spacecraft's fuel cell. The drop in pressure reduced the flow of gas, thus cutting the fuel-cell power output.

While reports circulated that the mission would have to be aborted early, NASA officials attempted to find the cause of the malfunction and to determine what fixes might enable the flight to continue.

Flight Director Chris Kraft reported that the probable causes were either a short in the heater designed to increase the temperature of the oxygen or a broken wire in the heater switch circuit. The malfunction occurred shortly after insertion of *Gemini 5* into orbit.

- **Cloud lifts**—The pessimistic outlook changed suddenly when flight control officials discovered that the oxygen pressure stabilized at 60 psi. Once this took place, officials knew that there would be a slow but continuous increase in the pressure as the oxygen was used up in the fuel cell and the fuel system was purged.

This is exactly what happened. By the fourth day of the flight, the oxygen pressure had increased to 107 psi and officials flatly predicted that the full eight-day-duration flight could be accomplished. Surprised NASA officials also found that the fuel-cell power production of 40-50 watts was sufficient to conduct the planned experiments and other flight functions. As a safety factor, the spacecraft was flown in a powered-down condition when the power was not needed for flight activities.

- **Records topple**—On Aug. 24, as *Gemini 5* rolled up 3½ days in orbit, Astronaut Cooper—who had previously chalked up a 34-hr., 20-min. flight on May 16-17, 1963—set the record as the astronaut with the most flight time in space.

On Aug. 26, as the spacecraft began its sixth day of flight, it set the new world record for manned spaceflight duration. The 120 hours which it had rolled up eclipsed the old record set by Russian Cosmonaut Valery Bykovsky of 119 hrs., 6 min. June 14-19, 1963, in the *Vostok 5* spacecraft.

Gemini 5 whirled on and it seemed certain that it would also give the U.S. the world record for total man-hours in space at the end of its 191-hr., 3-min. flight. As the spacecraft moved through its sixth day in orbit, there appeared to be no technical problems serious enough to jeopardize its success. Re-entry and splashdown 500 mi. southwest of Bermuda was expected at 10:59 a.m. EDT on Aug. 29.

- **Rendezvous exercises**—Loss of oxygen pressure in the fuel-cell tanks did nullify to a certain extent space agency plans to check out the spacecraft radar with the Rendezvous Evaluation Pod (REP). The pod was successfully jettisoned from the spacecraft and it trailed *Gemini 5* by about 1,000 ft. Because of the low power supply, NASA officials scrapped plans to use the Orbital Attitude Maneuvering System (OAMS) to move the spacecraft closer to the pod. The experiment was not a total loss, however, because the *Gemini 5* crew tracked the pod for about a half

hour with the radar. Useful range and range-rate data was obtained and Kraft declared that the radar system was qualified for use in *GT-6,* the first actual rendezvous and docking mission in the *Gemini* program.

● **Shadow rendezvousing**—Of far more importance to *GT-6,* however, were the rendezvous maneuvers initiated as the spacecraft made its 32nd revolution around the Earth on Aug. 23.

NASA officials decided to have the *Gemini 5* rendezvous with a phantom *Agena* upper stage as a replacement for the lost opportunity to rendezvous with the pod.

The test assumed that the *Agena* was launched on time into a nominal orbit ranging from 123.5 mi. perigee to an apogee of 183.2 mi. It also assumed that the rendezvous maneuver was being attempted on the spacecraft's fourth apogee, as it will be during the *GT-6* mission.

First phase of the maneuver took place at 12:50 p.m. As the spacecraft reached its 32nd perigee, the aft thrustors of the OAMS system were fired for 28 seconds to reduce its apogee from 207 mi. to 194 mi.

The second step—called a phasing maneuver—began at 1:34 p.m., while the spacecraft was reaching its 33rd apogee. The aft thrustors were again fired for 22 seconds, achieving a velocity of 15.6 fps and putting the spacecraft into a perigee of 113 mi. The OAMS burn also established an orbit insuring a flight-duration capability of at least 11.5 days.

At 13 minutes prior to the 33rd perigee, the *GT-5* astronaut crew completed a plane-changing maneuver. The spacecraft was yawed 90 degrees left and the aft thrustors were fired for 19 seconds. This successfully changed the orbital plane by the desired 0.2 degrees.

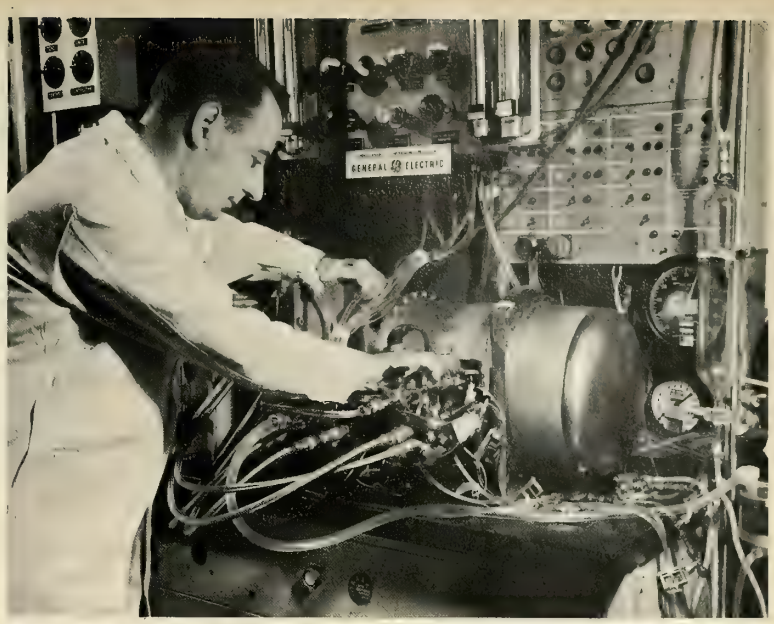
The last maneuver occurred at 3:06 p.m. when the spacecraft reached its 34th apogee. The co-elliptic maneuver required a 22-second burn of the thrustors as the spacecraft pitched down 16 degrees to increase its perigee to 124 mi. At the end of the maneuver, *Gemini 5* was in an orbit ranging from 124 to 194 mi. with a period of 95 minutes. Officials estimated that the phantom *Agena* orbit at that point was 141 mi. perigee and 210 mi. apogee. This placed the *Gemini 5* only 16 mi. behind the ghost *Agena,* very close to the planned 15-mi. separation which NASA hopes to have on *GT-6* just prior to the final closing and docking maneuver. This last maneuver was not attempted on *Gemini 5* because of the need to conserve OAMS fuel.

● **Man's military role**—*Gemini 5* during the course of its various experiments also made an impressive justification for a manned military space program. The two astronauts on Aug. 24 twice spotted objects on the ground in a dramatic display of astronaut visual acuity. They observed a *Minuteman* missile as it was launched from Vandenberg AFB, Calif., and took photographs of it. The missile launch was also tracked by infrared sensors aboard the spacecraft.

The crew also sighted a series of blocks laid out on the ground about 45 mi. south of Laredo, Texas, and reported the direction in which the arrows in the center of the blocks pointed. A ship, believed to be the U.S. Navy carrier Lake Champlain, was also photographed as it cruised in the South Atlantic Ocean.

On Aug. 25, after 96 hours, 51 minutes of flight, the astronauts saw and tracked with their IR sensors a rocket sled ignition at Holloman AFB, N.M. Again, after 97 hours and 28 minutes in orbit, the two astronauts reported seeing a *Minuteman II* launch only a second or two after ignition at Vandenberg AFB. They also reportedly saw an airplane in the area shortly before launch.

As the flight continued, both astronauts appeared to be holding up well after the almost endless hours of weightlessness. *Gemini* space medicine experts reported that both the blood pressure and heart beat of both astronauts was well within a nominal range. Although early in the flight both reportedly had trouble sleeping and eating as much as flight officials had wanted them to, their performance of these functions improved as the flight progressed.



GEMINI FUEL CELL shown during test at Schenectady laboratory when it was run through a 46-day test simulating 750 Gemini orbits. Test included continuous run equivalent to three 14-day missions such as that planned for GT-7, after which it delivered high power for another eight hours before test was concluded. Fuel cell proved in Gemini 5 flight to be far more reliable and flexible than NASA had hoped.

● **Fuel cell leeway**—As the fuel cell racked up time, *Gemini 5* observers were becoming more aware of the cell's operational latitude.

"We have found that maybe we don't have to fly the reactants at the super-critical state," Flight Director Kraft said. This is the "slushy" state described as being neither a gas nor a liquid and totally without a liquid level line.

"In fact, if we had 20-20 hindsight that the pressure drop would have stabilized at 70 psi, we could have continued with the Rendezvous Evaluation Pod exercise—because we now know that we can get 50 amps out of the system at the pressure we had."

Curves plotted by McDonnell Aircraft Corp. (prime contractor for *Gemini* spacecraft) "show we can get 50 amps all the way down to 55 psi," he said.

MAC engineers powered up a fuel cell in the St. Louis plant vacuum chamber during the early portion of the mission to evaluate the low O_2 pressure operating conditions of the spacecraft power source. This simultaneous test gave mission controllers the confidence to purge the O_2 side of the fuel cell even though the pressure was far below the manufacturer's recommended purge level of 200 psi. ■

AES Urged as Transition Space Effort

Congress told five alternative programs can be developed from Apollo technology; NASA stresses urgency of nuclear-rocket funding in FY '68

by Heather M. David

NASA HAS OFFERED Congress five alternate space-program packages which could be drawn out of the *Apollo Extension Systems* to cover the nation's space goals for the next 10-15 years.

If the nation decides to pick up the option on one of these packages, it would entail the development of a new orbital space station—with funding beginning in the 1968-69 period—and/or the development of a nuclear upper stage rocket for the *Saturn V* beginning in 1968, and a lunar base sometime thereafter.

NASA Administrator James E. Webb, in testimony before the Senate Aeronautics and Space Sciences Committee, cautioned against making a decision now on the next step beyond the development of the *Apollo* technology.

He pointed out that since the space budget has settled at a yearly level of from $5 to $5.25 billion, large new projects cannot be added just now without a substantial increase in the level. Had the level been the $5.75 billion originally planned, he indicated, a reduction would have occurred at about this time that would have allowed the addition of new programs.

The initial step, the *Apollo* Applications or *Apollo Extension Systems* program, was urged by almost all the witnesses before the committee. One-hundred fifty experiments already have been listed by NASA for both Earth-orbital and lunar missions using modified *Apollo* hardware.

Price of the *AES* program, said Dr. George Mueller, Associate Administrator for Manned Spaceflight, would be about $1-2 billion a year for operational costs. Expense of tailoring the *Apollo* to meet the needs of an expanded program would be $50-$100 million or a little more each year for new hardware, he told the Senate Aeronautics and Space Committee.

Time-frame for such a program, Mueller said, would require a decision in mid-1966 to begin hardware developments in order that they would be completed by 1970 to extend to the full extent the *Apollo* capabilities. In January, 1966, final definition of the payload integration activity can begin with overall program definition completed in July, 1966.

The committee, which is holding hearings on post-*Apollo* goals because of its concern over the lack of future commitments, elicited the estimate that a decision for a follow-on program would have to be made in FY 1968 or 1969 for the next major step, whatever it may be. Associate Administrator Dr. Robert C. Seamans said flights of a follow-on system would begin in the mid-70's.

Seamans estimated that the cost of a follow-on space station could range anywhere from $1-5 billion.

Concern over the future of the design team for the *Saturn V* and *Apollo* systems was expressed by NASA Administrator James E. Webb and other NASA witnesses. Noting that he had just returned from a tour of major contractors and NASA facilities, Webb said the problem of what these men will do is "very fresh in my mind." In the next six months, he said, the top people who performed the initial planning and design will be out of work unless a decision is made to upgrade the equipment for future programs.

One of the bases for the program packages NASA has outlined is the development of direct lunar ascent capability, requiring a nuclear upper stage for the *Saturn V* rocket.

Decision to begin flight hardware—which would cost a little more than $1 billion, according to Harold Finger, head of the joint AEC-NASA nuclear propulsion effort, must be made in FY 1968. He also urged the go-ahead for the flight nuclear rocket—which would generate from 200,000 to 250,000 lbs. of thrust—on the basis that it should

Satellite Navigation Nears Tactical Use

THE DEFENSE DEPT. is approaching a point at which it may be able to apply satellite navigation to tactical limited war situations that require precise knowledge of unit position in relative coordinates. That's what Dr. Harold Brown, Director of Defense Research and Engineering, told the Senate space committee last week.

The development has been made possible by the fact that much simpler systems will soon come into use, because of experience with the *Transit* navigation satellite and satellite-gained geodetic information concerning the precise shape of the Earth and its magnetic field. These will make possible the publication soon of a satellite ephemeral almanac by DOD that will permit the use of a simpler navigation satellite as well as simpler ground and shipboard equipment.

Applications of the navigation satellite to limited war situations, Brown said, include: 1) air and surface target coordination between multiple units; 2) the spotting in local map coordinates of landing and artillery units; 3) over-the-horizon shore and tactical ballistic missile bombardment; 4) the determination of land and sea target coordinates to fire-control accuracies by aircraft photo-mapping methods; 5) tactical coordination and control of carrier operations; 6) scheduling and control of amphibious and combat ground forces, including the mobile army; 7) rendezvous-at-sea replenishment operations under radio and radar silence.

Brown also disclosed, in testimony on future DOD space programs, that the infrared detector satellite (formerly called *Midas*) will be considered for development operationally if the current R&D effort indicates that the approach is competitive with other potential solutions to the early warning problem.

DOD has become increasingly interested in investigating the potential of a synchronous meteorological satellite, Brown added. He said that from a military standpoint, the *Tiros* Operational Satellite (TOS) system cannot always satisfy the DOD's needs. If the synchronous satellite experiment now jointly planned with NASA and the Weather Bureau should confirm DOD's thinking, Brown said, the 1970-1975 time period should see a combination of synchronous satellites augmented by one or two polar orbiting satellites for worldwide coverage.

be available in order that a decision can be made whether or not to embark upon manned flights to the planets.

● **Apollo alternatives**—For purposes of aiding national planning, NASA has grouped the possible missions which would use *Apollo*-based hardware in the early phases into five packages. The first group of missions would exploit direct economic benefits available, the second lunar exploration and science, the third planetary exploration and science.

The fourth plan outlined by Dr. Mueller would be one in which the U.S. would exert maximum effort to become preeminent in Earth-orbital, lunar and planetary activities, exploiting all technology available. The last—and presumably the most attractive—would be a balanced program, which Mueller described as a "cost-effective combination of economic benefits, lunar and planetary exploration and science."

● **Direct economic benefits**—Achievement of immediate and practical payoffs to mankind on Earth would fall into a program with primary emphasis on direct economic benefits.

The first step would be the use of *Apollo* Earth-orbital systems with mission durations of 45-90 days. These missions would include remote Earth-sensing, astronomy, biosciences, physical sciences, and space operations/technology configurations, with the major emphasis on science and applications experiments (M/R, Aug. 9, p. 14; Aug. 16, p. 14).

NASA is working on "experiment pallets" to be used for the compatible grouping of experiments in the service module. According to Mueller, the pallet provides the capability for a payload of 3,500 lbs. of experiments with their own power and environmental control systems, and could be accessible to the flight crew by extravehicular activity.

These pallets would be assembled at Cape Kennedy and tested and inserted into the Service Module with a minimum change in basic spacecraft. A decision is being made as to what NASA facility should have a modifications center where experiments would be assembled and installed in the Lunar Excursion Module (LEM) laboratories.

Mueller pointed out that this period would also give NASA its first experience with multiple rendezvous and docking of LEM-derivative spacecraft, which will provide increased laboratory capability and mission duration.

With the experience of the Earth-orbital phase in hand, the manned space flight director said, NASA would then be in position to define system requirements for an orbital station and its accompanying logistics system. The orbital station would be sized for six, nine or even more men, boosted by either a *Saturn IB* or *Saturn V* vehicle.

Logistics systems for the station would evolve from *Apollo* and *Apollo* applications technology. A key objective during the period of the orbital stations would be development of long-duration, minimum-maintenance subsystems for electrical power, life support, and communications.

The next step probably would be the evolution of capability from the orbital station towards an Application Center and a Research Laboratory facility, the research laboratory then leading to a larger-scale research complex. Emphasis, Mueller said, would be on conducting scientific experiments in the biological and physical sciences and would include larger-size astronomical observatories, and support for applications activities.

Eventually, the program would result in such practical components as a resource inventory station for the monitoring of geological and agricultural resources; a weather station for long-range global weather forecasting with increased accuracies; a communication station providing real-time, direct FM and TV broadcasting, and support for military space activities aimed at national security problems.

In the meantime, the logistics system would be developed into an advanced logistics system for significantly more economical delivery of payloads into low-altitude polar and synchronous orbits. A requirement of an advanced logistics system would be reusability and capability for atmospheric maneuvering and land-landing.

● **Lunar exploration**—Should the national decision be to accomplish lunar exploration and to advance lunar science, program emphasis for *AES* would go to extensive lunar operations, both in orbit and on the surface.

Certain areas on the Moon would first be selected for further surface exploration, and an unmanned LEM modified to serve as a shelter would be placed on the lunar surface. The two-man crew would land in a normal LEM taxi, possibly using such equipment as a small, manned lunar roving vehicle, a manned flying system, a lunar drill and scientific instruments.

With the development of a direct flight system, a temporary station would be built, followed by a permanent facility. Complete lunar surface reconnaissance, investigations of the lunar interior, and explorations of the most interesting surface characteristics, such as the highlands and craters, would be accomplished.

The first permanent station probably would be similar to the one serving as a permanent staging base to the Antarctic continent at McMurdo Sound, Mueller said. It undoubtedly would be powered by a nuclear reactor system and utilize lunar resources as much as possible.

An even more ambitious research base on the Moon might be needed. This would be made up of a large number of specific research facilities directed at various fields of interest, such as astronomy, geology, geophysics, bioscience, operations and others, Mueller said.

The ultimate in manned utilization of the Moon, Mueller said, would be the establishment of a resource processing station, used to obtain water, minerals, oxygen, or other materials that could be valuable either in lunar exploration or perhaps in more distant deep-space undertakings.

● **Planetary program**—The fly-by mission mode offers the best opportunity for performing manned planetary exploration with minimal cost and at an early date, Mueller said, because of its comparatively modest demands for new launch hardware and spacecraft subsystems.

The development of communications, on-board power generation and crew life support would have to be provided, probably as an outgrowth of the same orbital station in the Earth-orbital phase. From this would evolve planetary spacecraft modules, in the same manner as the research facility of the Earth-orbital program. These also could be tested on the Moon, as a trial for emplacement of equipment on the surface of the planets. The advanced logistics system developed for Earth-orbital missions also would have its part.

With the advent of nuclear stages and advanced launch systems, landings would be made on near planets, leading ultimately to near-planet stations and distant-planet fly-by systems. The planet stations would benefit from research done on the resources inventory station.

● **No decision soon**—In other testimony, Presidential Science Adviser Dr. Donald F. Hornig downgraded the ability of the United States to make a decision—for 10 years—whether a manned Mars mission should be made. He indicated that one would have to estimate a cost of at least $100 billion for such a venture, based upon *Apollo* experience. He also said that planning at this time for lunar bases seems quite unrealistic.

Hornig endorsed the *AES* concept, and said that it was "clearly important" that capabilities of the *Apollo* be extended so that after the first expedition or two astronauts will be able to stay on the Moon for a week or 10 days. "It seems to me we must make provision soon to extend the stay time, to provide mobility on the surface, and to deliver suitable tools to astronauts to carry on their work." ■

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Technical Countdown

PROPULSION

LPC Lists 156-in. Motor Contractors

Approximately 60% of the $5.5-million Air Force funding to Lockheed Propulsion Co. for the two 156-in. solid motor programs will go to subcontractors providing nozzles, propellant chemicals and other components. The first motor will be a segmented unit 75 ft. tall holding 700,000 lbs. of propellant generating 3 million lbs. thrust. The second unit is a monolithic motor 33 ft. high developing 1 million lbs. thrust. Both are refurbished units from previous programs. Rohr Corp. will insulate both cases, modify the second unit and assemble the 3-million-lb.-thrust nozzle. HITCO will build the smaller nozzle. Pittsburgh Des Moines Steel Co. is supplying hardware for the second motor and steel shells for both nozzles. Standard Steel Div. of Baldwin Lima Hamilton will also provide parts for the second motor. Steel forgings for the nozzles will be supplied by Earle M. Jorgenson Co. and Standard Steel. More than 400 firms will provide materials or services for the LPC 156-in. solid motor program.

Thiokol Studies Minuteman/Titan III-X

Systems engineering analyses and design definition of the M-55 *Minuteman* first-stage motor as strap-on thrust augmentors to the non-manrated *Titan III-X* Air Force launch vehicle will be provided by Thiokol Chemical Corp. The firm's Wasatch Division has initiated a two-month study program under a $125,000 contract with Air Force Space Systems Div. The concept had been advanced by Thiokol some time ago as an economical means of uprating the proposed *Titan III-X*. There would not be any heavy development expense since the M-55 is already operational and in production for the *Minuteman* ICBM system. The division will conduct trade-off studies to define the complete thrust-augmentation stage, associated ground equipment and pre-launch facility requirements.

ELECTRONICS

Penn State to Continuously Monitor Ionosphere

Two engineers at Pennsylvania State University's Ionosphere Research Lab will continuously monitor the ionosphere, using radio transmitters and a phase interaction theory partially founded on the Luxembourg effect. Two transmitters are synchronized to cause their signals to interact at a precise altitude within the "D" region. Altitude is easily changed to cover the entire ionospheric region. One transmitter sends short pulses of radio pulses at 2.2 million cycles per second. These are reflected back by the ionosphere. A second transmitter beams a 300,000-cps burst at every second burst from the first transmitter. The "disturbing" signal from the second transmitter warms the ionosphere, changing its electrical properties. This disturbs the pulse from the first transmitter, and the signal difference can be detected on the ground. The technique, now being funded by the Office of Naval Research, can determine changes in the ionosphere caused by natural or artificial disturbances such as sun spots, solar flares or astronomical explosions. The $164,000 contract will go toward uprating existing equipment to allow a complete sweep of the D-region every 30 seconds.

OGO-1 Finds New VLF Noise

New phenomena have been observed with the VLF experiment on *OGO-1*, a joint project of Stanford University and Stanford Research Institute. Beyond the altitude where normal whistler propagation cuts off, a strong fluctuating noise has been detected, with a spectrum that sometimes extends over the full 200 cps to 100 kc range of the *OGO-1* receiver. The noise has been observed between 5 Earth radii and the *OGO* apogee of 24 Earth radii. Whistler emissions observed include hiss, chorus, risers, and constant tones. Whistler-triggered emissions are common, including one type that has a direction of travel apparently opposite to that of the parent whistler. Ground transmitter signals received by the satellite show frequency-selective fading, which suggests multi-path propagation.

Optics Boost E-M Surveillance

Good estimates of the nature of radar signals received from transmitters "a considerable distance over the horizon" may be made using optical data processing. In classified work at Stanford University Electronics Laboratory, the Fourier transforming property of thin lenses has been used to measure the autocorrelation function of a raster modulated with a simulated radar signal at low signal-to-noise ratios. Radar autocorrelation functions with large time-bandwidth products may be generated. Pulse width, pulse repetition frequency and transmitter power can be estimated from these functions.

Hybrid Computer to Aid Saturn Vehicle Studies

A hybrid computing system will be delivered to NASA's Marshall Space Flight Center early in 1966 for use in *Saturn* booster design studies. NASA officials claim that the complex *Saturn* studies require the interrelated abilities of digital and analog computing techniques to simulate the flight data system and booster dynamics. The hybrid system, supplied by Electronic Associates, Inc., for $875,000, will also be used for the reclaiming and re-use of boosters and for multi-staging control studies. The latter involves the dynamics related to physical bending of the booster vehicle, propellant sloshing and other inputs such as wind profiles. The computer system is slated for work in classified advance research applications at the Huntsville complex. This is the second major hybrid system purchased by NASA from Electronic Associates.

ASTRONAUTICS

Avco Continues Decoy Study

Penetration aids covering the effective delivery of ICBM warheads in the 1970's will continue to be studied at Avco Corp.'s Research and Advanced Development Div. under a $550,000 follow-on contract from DOD's Advanced Research Projects Agency through the Air Force's Ballistic Systems Div. The general aim of such studies is to increase the ability of U.S. ballistic missiles to succeed against an enemy's missiles defense system. The Avco program is known as ADTECH—the advanced decoy technology program. The project will be managed by D. Hritzay under Avco/RAD's Advanced Systems and Penetration Aids Directorate.

Program Promises Better Instruments

AFCRL's Project 6682 will yield meteorological systems to aid in launch operations and missile design; budget is modest

by Michael Getler

BEDFORD, MASS.—Scientists at the Air Force's Cambridge Research Laboratory are now studying or developing about two dozen new techniques for improving the quality of meteorological data necessary to support operations at all U.S. military missile test ranges.

The techniques under study run the gamut from ground-based lasers to rocket-borne Bremsstrahlung densitometers, and from low-altitude measurements to 600,000-ft. satellite altitudes. The program is carried forward under Project 6682, an Air Force effort that began in 1960 and has already yielded far more important improvements and promises than its rather austere budget and work force levels would normally indicate.

The program, managed by the Electronics Systems Div. here, is budgeted at $640,000 for FY '66, a decrease from the $715,000 FY '65 level. However, project sources say that the FY '67 request will be higher than the FY '65 figure, and that the program in the past has run as high as $1 million annually. Seven professionals at AFCRL comprise the scientific staff for the project.

The development of small, new rocket-mounted instruments and telemetry packages has also opened a wider selection of sounding rocket launch vehicles for the Air Force, an option that could save as much as $2 million annually, according to ESD officers, in sounding rocket procurement costs.

The work is also of major importance to missile designers, particularly in terms of accurately defining the atmospheric density component of launch phase and re-entry effects upon the vehicle.

Engineers here say that they are now pushing the point at which the atmospheric density correction has become the limiting characteristic in taking out the noise factor during the re-entry period.

● **Scope of program**—The 6682 effort is broadly focused into three atmospheric regimes. Scientists are attempting to improve wind, temperature, and humidity measurements in the segment below 100,000 ft.; wind and temperature measurements between 100,000 and 300,000 ft.; and primarily density measurements in the higher altitudes to 600,000 ft.

While this is done primarily through rocket-launched devices, there are also important efforts under way to improve ground-based lightning storm warnings, wind gust and lateral and vertical wind loading measurements, low-level atmospheric sounding methods, and several other measurements necessary for both routine range support and detailed missile design.

Because of the large number of individual meteorological measurements needed for range support, the large number of ranges to be supported, and the amount of activity at each range, the 6682 R&D effort has been closely directed toward coming up with inexpensive hardware with low day-to-day operational costs, which is easy to handle and in some cases re-usable.

Although 6682's efforts are applic-

AIR FORCE Capt. T. J. Smith, left, project scientist for Project 6682, points out miniature transducers on sonic anemometer to Capt. Ernst Kellerstaff, project manager.

able to all U.S. military ranges, the Eastern Test Range (ETR) reportedly has the most stringent requirements and is generally responsible for generating the standards for new instruments.

Project scientist for 6682 at AFCRL is Air Force Capt. Thomas J. Smith. ESD project manager is Air Force Capt. Ernst J. Kellerstraff.

A rundown of those programs now in development under 6682 that are likely to bring important advances to range meteorological support and missile design within the next 12-24 months follows.

● **Rocketsondes**—With balloon soundings limited to roughly 100,000 ft., AFCRL has engaged in an extensive effort to improve the sounding equipment packages carried aboard rockets able to reach much higher altitudes.

Now in development by Bendix for AFCRL is the DMQ-9 transponder, which will go aboard the widely used *Arcas* sounding rocket to provide both temperature and wind data to altitudes between 80,000 and 225,000 ft. Development is expected to be completed late this year, according to AFCRL. Current *Arcas* rockets carry a transmitter that permits only temperature measurements.

A development of major importance carried out under 6682 has been the transformation of the very small *Loki*-type rocket, originally developed by the Navy as an anti-aircraft rocket, into the *Loki-Dart* meteorological rocket.

The *Loki* solid-motor rocket burns for about 2 seconds, to about a 1-mile altitude, and the unpowered *Dart* second stage, only 1.375-in. in dia., carries a 1.5 lb. payload to the vicinity of 200,000 ft. AFCRL is now involved in attempts to develop miniaturized solid-state instrumentation for the *Loki-Dart* that can be packaged in this very narrow diameter and can withstand the 200-g accelerations. A transmitter package has already been developed, and a transponder package is now being developed by Metro-Physics, Inc., of Santa Barbara, Calif.

Availability of the transponders for the *Dart* will probably signal an important shift to the smaller and lower-cost *Loki* system and away from the *Arcas* for sounding missions at these altitudes. Based on purchase of between 1,000 and 1,500 rockets annually, AFCRL estimates that the *Loki-Dart* approach will save more than $1 million. The smaller system is also far less wind sensitive because of the high acceleration, and can be fired in winds up to 30 knots. The smaller system also involves a minimum of handling effort.

● **Ballute**—While rockets offer major advantages in comparison to balloons in use at missile ranges because of their ability to quickly get to altitude and therefore report just before a missile launch time, there are several problems attached to the upper atmosphere reporting and descent phase during a parachute recovery.

To attempt to overcome this, Goodyear Aerospace, under 6682 contract, is now developing a ballute (balloon-parachute combination) retardation and stabilization system which AFCRL scientists hope will yield several thousand feet of more useful flight reporting time and many more data points. The system was tested last month, unsuccessfully, in drop tests from balloons. Scientists are optimistic, however, about eventually solving problems and being able to use the ballute with *Arcas, Loki,* and even smaller-diameter rockets under evaluation for a low-level sounding system. Packaging problems for these very small launchers are expected to need most attention.

● **Density measurement systems**—Because of the critical nature of air density measurements, AFCRL has taken several approaches, involving both new techniques and refinements of existing systems, to attempt to improve its data in this area. Most approaches involve drag or back-scatter measurements, which are used to equate density. AFCRL scientists, however, are still looking for a real breakthrough in this field that would allow direct real-time independent density measurements.

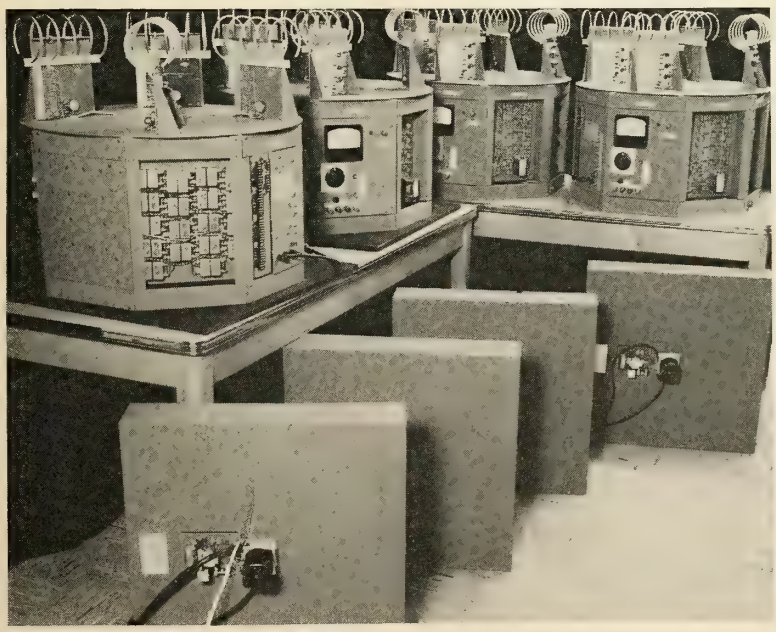
● **ROBIN**—Work is now under way to increase the altitude capability of the ROBIN (Rocket Balloon Instrument), a transparent sphere that is ejected at high altitude and tracked by ground-based FPS-16 radars to get density and wind data. The sphere has been reduced in size and weight and will soon be launched by a *Sparrow-Arcas* combination, which is expected to increase altitude from the 220,000-ft. *Arcas* levels to above 300,000 ft.

Despite these improvements, the technique is expensive, requiring use of the radars, and is also limited mostly to ETR and WTR because of the need for the precise radar tracking.

● **Accelerometer sphere**—AFCRL, through contracts with G. T. Schjeldahl Co. for the sphere and the Univ. of Michigan for the accelerometers, has reduced the diameter of this inflatable drag-sensing system from 9 ft. to about 4 ft. and successfully flew it aboard a *Nike-Iroquois* three weeks ago. The new sphere has a 4-ft. solid center strut that improves rigidity and a new linear, three-axis accelerometer package. Smaller-diameter spheres are expected to be developed that would allow use of the *Sparrow-Arcas* to replace the *Nike,* and further reduce costs. The sphere is designed for operation in the 270,000-450,000 ft. regime.

● **Ram pressure density gauge**—Under development now by the Univ. of Michigan, this device is being packaged to fit into the *Sparrow-Arcas* and to make rapid measurements along the flight path from 150,000 ft. to about 300,000 ft. The gauge has been flown aboard the *X-15* at altitudes below

EQUIPMENT for four SPARSA sites is readied at Litton Systems, Inc., developers of the new lightning warning system for AFCRL. Equipment is now being evaluated.



100,000 ft. and is now being redesigned for rocket use. AFCRL scientists hope to get measurements below the current 1-mm capability of the gauge, down to about 0.1-mm. The system has the advantage of making density measurements in a matter of minutes during its ascent, which could immediately precede a missile or space booster test flight.

This gauge, and a new Bremsstrahlung-effect densitometer under development, could also be used, if they are successfully developed, to fill an AFCRL requirement for an on-board densitometer for use with an Air Force standard launch vehicle to improve re-entry prediction.

● **Bremsstrahlung densitometer**—Another densitometer technique that measures on the way up is under development by Parametrics, Inc., Waltham, Mass. The device makes use of the Bremsstrahlung effect of X-ray backscatter to measure density in the upper atmosphere. An electron gun on board is used as the source. The device is expected to get its initial flight test aboard a *Nike-Cajun* later this year, but it is thought to be more than two years away from any operational use. The system initially will be tested to altitudes of about 450,000 ft. but eventually may be extended to 600,000 ft. Size reduction efforts would follow successful test flights to allow use with smaller, less expensive rockets.

Also beyond the immediate two-year period are two other density sensing techniques designed for use at high altitudes. Both are in the feasibility study stage now, and both would probably require *Nike-Iroquois* boosters.

One is a dumbell-shaped spinning device that would be released at 600,000 ft. with spin decay rates measured through descent to about the 300,000-ft. level. The other approach involves density measurements to 360,000 ft. by measurement of the fluorescence of nitrogen in the atmosphere.

● **Low-level sounding system** (LLSS)—AFCRL will press to get this urgently required system into service at both ETR and WTR within two years. The system would use low-cost *"Cricket"* rockets to sound the lower portions of the atmosphere, below normal balloon sounding levels. Included would be measurement of temperature, humidity, index of refraction, and wind shears from the surface to the 3,000-ft. level.

Texaco's *Cricket* rocket is a very small system, operated by one man, which uses a CO_2 charge, and which costs about $70 each. The system can also be recovered by a parachute, and one rocket has reportedly been re-used 10 times.

Key to the program is the transponder package for the *Cricket*. AFCRL is expected to select a contractor for this development within the next three weeks. The instrument techniques may also be extended to balloon use.

● **Balloon instruments**—In addition to basic materials efforts related to improved balloon operations, AFCRL is also sponsoring important work in new balloon instruments.

● **Multi-channel radiosonde**—Under development by Litton Systems, Inc., this balloon-borne device is designed for operation to 120,000 ft. and is expected to be capable of rapid and simultaneous transmission of several channels of meteorological data, including index of refraction information. It is hoped the device will provide more data and more efficient handling than is possible through current commutated carrier operations. The device has been built and is now under evaluation.

AFCRL is expected to evaluate off-the-shelf three-channel recorders produced by Hewlett-Packard and Texas Instruments to use with the radiosonde.

● **Microwave refractometer**—In about two years, AFCRL hopes to have this device ready to operate with the radiosonde to altitudes of about 40,000 ft. The instrument will be designed to derive index of refraction to a resolution of 1-2 N-units. Atlantic Research Corp. and the Univ. of Western Ontario are doing work on this.

● **Ground instrumentation**—Included in 6682 projects are two additional methods to determine atmospheric density using ground-based techniques, and two other systems for very precise surface wind measurements and electrical storm warnings. Both of these latter systems are expected to play a major role in future operations at missile test ranges.

● **Laser searchlight**—A ruby laser system is now operating at the Univ. of West Indies in Kingston, Jamaica, and the results of tests will be evaluated for feasibility of using back-scattered laser light as an indirect indication of density. The system is potentially usable to altitudes of 180,000 ft., says AFCRL.

● **Meteor trail measurements**—AFCRL is also supporting work at the new Havana, Ill., site established by Harvard's Smithsonian Astrophysical Observatory to track the ionized trails of meteors in the region between 260,000 and 305,000 ft., an area in which there is considerable meteor activity. The intent is to gather continuous wind and density data for this region. The present site, which is expected to become operational next month, includes eight tracking stations, but AFCRL estimates that a smaller three-station complex could be useful for missile range work and cost about $300,000-400,000 to install.

● **Sonic anemometer**—Developed by Cambridge Systems, Inc., of Waltham, Mass., AFCRL scientists told MISSILES AND ROCKETS this device "will probably revolutionize the whole wind measurement field." The system is expected to go into service next year, probably finding wide use aboard missile and space booster gantries. AFCRL says the design is highly reliable and the key component of the instrument (the transducer) costs only $15. The anemometer reportedly gives highly precise wind direction and gust information to wind speeds of 150 knots—with a response time of 0.25 seconds—and can measure gusts as short as 0.5 sec. duration.

The digital read-out system presents east-west, north-south, up-down wind components separately.

AFCRL scientists say the miniature piezoelectric transducers are "the real breakthrough." These transducers transmit and receive ultrasonic pulses on a time-shared basis over a path of about 15 in., with transit times relating wind speed, and separate transducer pairs used for direction.

● **SPARSA**—Another key new system now being evaluated at ETR is Litton's SPARSA (Sferics, Position, Azimuth, Range, Spectrum Analyzer). This is a three-station network designed to provide warning of lightning activity in the area of missile launch sites.

The Litton system operates at 500-kc and provides counts of electrostatic activities to ranges out to a 200-mi. radius from a site. Sector scanning allows site operators to determine location and track movement. Indications of a change in the level of electrical activity will also be provided.

The system is expected to be extremely useful in helping missile launch engineers in making decisions whether to shut down launch pad activity because of impending lightning storms, when loading of LOX, for example, can be extremely dangerous. It should help to eliminate costly work stoppages when thunderstorms, with no electrostatic activity, approach. The Litton system reportedly worked successfully before the recent *Titan III-C* launch, which was delayed because of weather.

● **Future high-altitude rockets**—AFCRL scientists also are involved in studies aimed at providing a better high-altitude rocket system, able to lift 10-20 lb. payloads to 600,000-ft. levels, about two years from now. They expect to come up with this system primarily through marriage or modification of existing hardware. Atlantic Research Corp has already done a study for Project 6682 regarding some of the possibilities. Using this as a starter, scientists here expect to let contracts shortly to begin detailed exploration of some of these concepts and some of their own. Foreign rockets will also be taken into consideration. ■

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UTC Solves Scout Stage Spin Problem

Company expects 150-a-year sales of fourth stage with highest mass fraction boasted by operational solid; fixed-price contract met

by Robert Lindsey

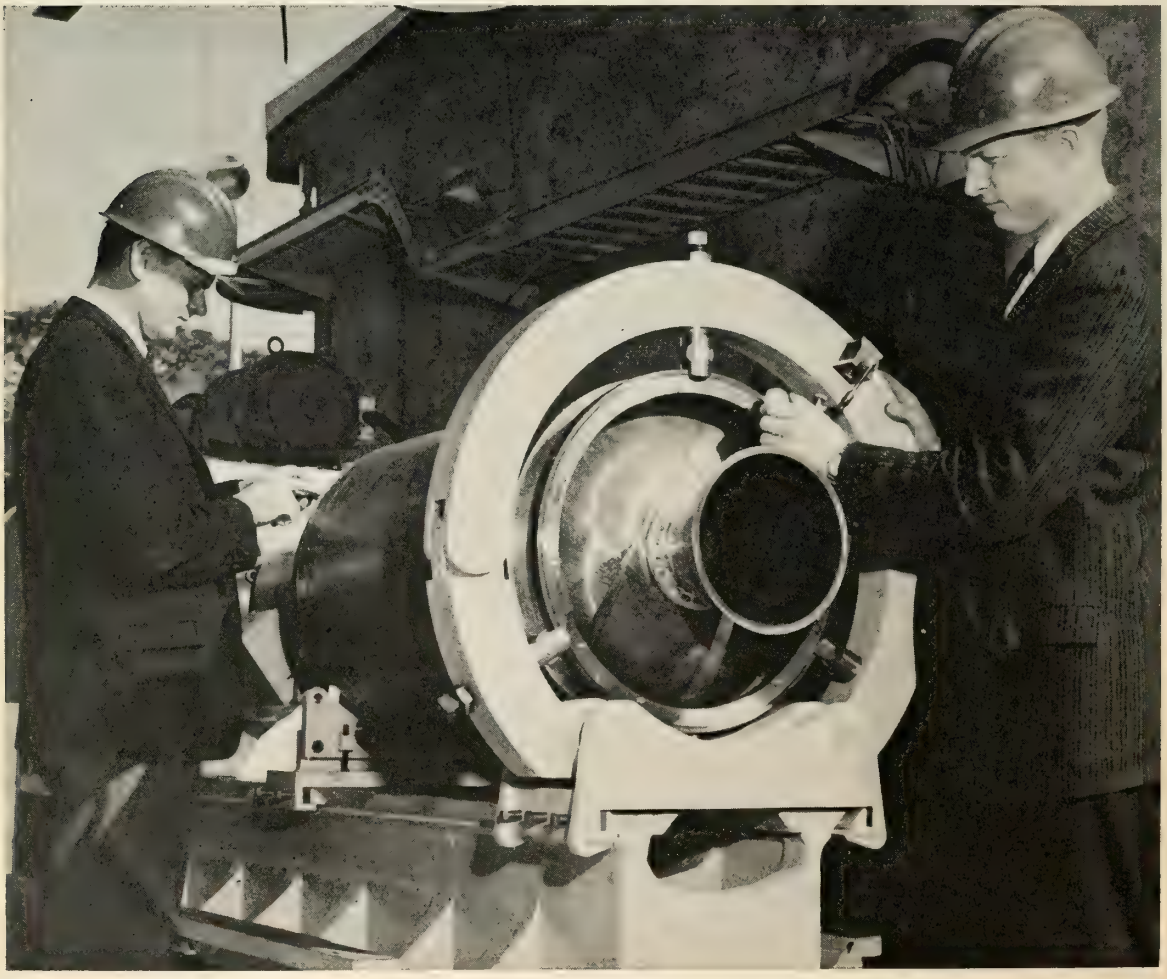
SUNNYVALE, CALIF.—United Technology Center's new high-performance *Scout* fourth-stage motor achieves the highest mass fraction of any operational solid motor and is the first rocket in a major launch vehicle developed on a fixed-price contract.

UTC officials here estimate they will sell about 150 of the new motors per year on a fixed-price, guaranteed-performance basis. Its utilization won't be limited to the uprated *Scout*. It has already been used as an upper stage with a *Thor* and plans are to use it atop the *Thor-Delta* and perhaps in other high-performance upper-stage applications for orbital, re-entry and probe missions.

The stage was flown successfully for the first time in early July in a classified launch atop a *Thor* from Vandenberg, AFB, Calif., and on Aug. 10 it performed successfully in the first flight of the uprated *Scout*.

The spin-stabilized FW-4S motor

UTC's 6,000-lb.-thrust glass-wound, fixed-price upper-stage motor being examined prior to static firing at the firm's Coyote, Calif., test site.



has altitude thrust of 6,250 lbs., weighs 658 lbs. and incorporates several significant state-of-the-art advances, Christian Fry, UTC's manager of solid propellant motors, told M/R. These include:

—The motor's filament-wound case is fabricated from an advanced high-strength glass developed by Owens-Corning Co., Santa Clara, Calif., which is 30% stronger than any glass used before.

—The nozzle, fabricated from an advanced low-density silica material, weighs only 11 lbs., 35% less than state-of-the-art levels.

—The motor features a unique "consumable" rocket-type igniter. An aluminum structure within the igniter burns during combustion and actually contributes to the motor's impulse.

Fry said these advances permitted the motor's record mass fraction of 0.922—the best yet achieved.

● **Like Titan fuel**—The rocket measures 19.6 in. wide and 58.5 in. long and contains 605 lbs. of aluminized polybutadiene acrylonitrile/ammonium perchlorate propellant, quite similar to the propellant UTC uses in its 120-in. *Titan III-C* motors. Action time is 30.5 sec. Nominal specific impulse is 245, with altitude impulse of 287.

Developed under contract from Air Force Space Systems Division, the motor was designed, developed and flight-qualified in less than a year, Fry said. The fixed-price contract was for approximately $1.2 million. Fry said it is the first time a major rocket stage has been developed on a fixed-price contract. He called the feat particularly significant because it required substantial state-of-the-art advances.

UTC said the motors will be sold on a guaranteed performance-replacement basis at $25,000 for 50 units or more, and $29,000 for 10 to 50 motors.

Use of the new motor on the *Scout* has increased its payload by more than 25%, permitting the SLV-1A vehicle to put a 188-lb. payload into a 600-n.-mi. polar orbit. With the *Thor-Delta*, it permits orbiting of payloads up to 400 lbs. in some missions. Payload and other details of the *Thor*/FW-4S configuration are classified.

● **Pressure vessel**—Fry said the Owens-Corning S-HTS Fiberglas/epoxy case has a nominal cylindrical wall thickness of 0.080 in. and the domes have optimum geodesic contours with a nominal thickness of 0.03 in. The case polar bosses are fabricated from aluminum, and aluminum interstage flanges are attached to the motor case through integrally wound Fiberglas skirts. The case is insulated with silica-filled Buna-N rubber. Fry predicts the high-performance Fiberglas will see wide use in the future, in the *Poseidon* fleet ballistic missile, for example.

Equally advanced, the nozzle is a composite structure utilizing an aluminum nozzle attach flange, an exit cone subassembly and a throat subassembly.

The exit cone consists of an ablation-resistant, graphite cloth, phenolic-backed with advanced silica-phenolic (foam ceramic) material which extends to the exit plane. It is reinforced by a 0.01-in.-thick stainless steel shell which provides structural rigidity. The steel shell is bonded and riveted to the aluminum nozzle attach flange.

The nozzle throat is graphite-backed with a ring of silica-phenolic material bonded and pinned to the attach flange. The nozzle half-angle is 20°, the nozzle throat diameter is 2.28 in., and initial expansion ratio is 52.8. The total package weighs only 11 lbs., 35% lighter than any comparable nozzle, Fry said.

The development program included four heavyweight subscale motor firings, two case-hydroburst tests, one case flight-loads test and eight flightweight motor static firings, followed by six flightweight static firings in the preliminary flight rating tests.

● **Finding formula**—Many of the engineering problems during development, Fry explained, involved selecting the optimum propellant formulation compatible with the 200-rpm spin-stabilization requirement specified for the motor.

Static tests in which motors were spun add up to 200 rpm showed that motor chamber pressure and burning rate were increased at spin rates above approximately 190 rpm.

In these early tests, centrifugal action resulting from the spinning caused the deposit of a substantial amount of aluminum oxide in the motor chamber.

In the early heavyweight motor subscale tests at 200-rpm spin-rate, as much as 12 lbs. of aluminum oxide was deposited in the chamber, resulting in intolerably high chamber pressure and other problems which degraded the motor's performance to an unacceptable level.

The problem was solved by using a finer grade of aluminum powder. The 40-micron average particle size power used in the initial three test motors was replaced with 15-micron particles, resulting in acceptable chamber pressure and a deposit of an acceptable 2 lbs. of aluminum oxide.

Maximum acceleration imposed on a 195-lb. payload is 22 g. The motor has an upper reliability level of 0.993 at a 90% confidence interval. ■

SPECIAL TEST FIXTURE spins solid motor at some 200 rpm while firing, effectively simulating flight conditions.

Ground-Station Automation Imminent

Ranges may have all operating functions controlled by one master computer; Defense Electronics wins Marshall Contract

COMPLETE AUTOMATION of telemetry ground stations may herald new developments in the man-machine interface in checkout stations for missiles.

Too often, range officials report, the ability of an operator to monitor displays, make quick decisions and initiate controls of functional operation has limited the usefulness of data-reduction stations.

When the man-machine interface is bypassed, a station can respond to varying operational parameters in a few microseconds and adapt itself to conditions providing optimum operation. This is particularly important in static tests of missiles, where the complete testing cycle is so short that there is no time for manual correction of errors or optimization of controls.

Defense Electronics, Inc., of Rockville, Md., recently won a $400,000 contract from NASA's Marshall Space Flight Center for a computer-controlled telemetry ground station. For the first time, all telemetry parameters will be selected and controlled by a general-purpose digital computer.

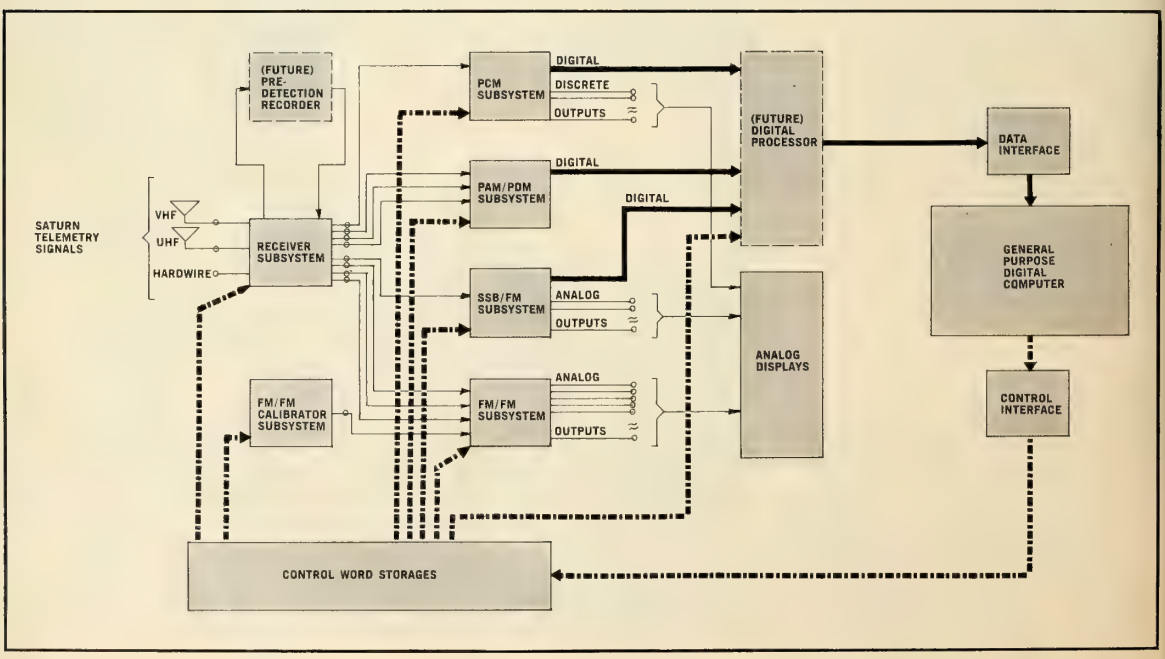
● **New subsystems**—A group of six subsystems will be designed and developed by DEI to receive and demodulate all types of *Saturn* telemetry data. One industry spokesman says these will set the pace for the aerospace industry in ground stations, since all operational functions will be controlled by one master computer.

The subsystems provide for demodulation of FM/FM, FM/FM/FM, PAM, PDM, PCM and SSB/FM data for real-time *Saturn* tests, and the processing of several of these types of data for computer entry. Each subsystem is under control of the computer, while another subsystem provides computer-programmed simulation data for station checkout.

One unique feature of the system is a VHF/UHF receiver subsystem, consisting of eight computer-controlled receivers. The computer will select any of 16 predetermined crystal-controlled carriers in the VHF or UHF telemetry spectrum, any of four IF amplifier bandwidths, and any of three video output characteristics, for each receiver in the subsystem. Predetection record and playback capability is also provided under computer control.

A single sideband subsystem will perform the operations necessary to restore to original form data which has been processed by a NASA airborne single-sideband telemetry assembly and to present this information, in analog form, at its output. The subsystem will also select any output of the single-sideband de-multiplexer and present data

Computer-Controlled Telemetry Ground Station



from the selected channel at its output in digital form.

● **Further details**—The PCM subsystem is a special-purpose data processor that accepts as an input a PCM wave train, synchronizes to the selected format, converts the serial information to parallel words, and decommutates 10 words with 10 bits of data each as 100 special-purpose discrete outputs. The major components of the subsystem are a bit synchronizer/signal conditioner, a serial-to-parallel converter, and a discrete-output/computer-control unit. Timing and other miscellaneous outputs will also be provided.

The PAM/PDM subsystem accepts three PAM or PDM inputs and converts these inputs into digital words which are presented at the subsystem output along with other information such as frame sync. and subframe sync. The subsystem is controlled by a 24-bit word via a digital control unit. The input format consists of a strobe and 24 parallel bits. Four of the bits are address instructions and the remaining 20 bits control the operating parameters.

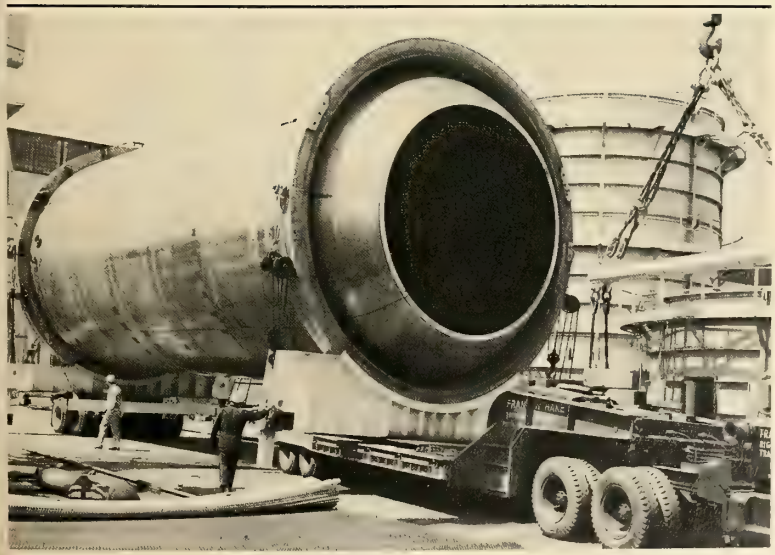
A subcarrier discriminator subsystem will accept three FM multiplexes, and is capable of simultaneously demodulating 36 FM signals from the three inputs. To demodulate triple FM intelligence, the inputs to two groups of seven low-order IRIG channels are capable of being patched to the output of any of the high-order channels. Tape recorder flutter is corrected on all discriminators from error signals appearing on any multiplex input. A switchable discriminator is provided in the system and switched remotely to any one of the multiplex inputs.

The sixth subsystem, a 5-point calibrator subsystem, is a source of accurately generated telemetry frequencies for IRIG channel 1-21, A through H, and special channels. The calibrator provides for automatic selection of five frequencies within each channel. It also provides for automatic sequencing of these frequencies with selectable dwell time on each frequency.

● **Other uses**—A significant aspect of the system design, according to DEI, is that it can be used not only in static missile firings but also in reception of data from an adaptive airborne telemeter.

In this operation, the received data format may change without advance warning as the transmitting station adapts itself to a new set of conditions or a new type of data. It is necessary that the receiving station be able to recognize the new condition, readjust itself to the mode of operation, and be operable in the minimum practical time. Without closed-loop computer control, this is an untenably slow process in real-time operation.

Other applications of the computer-controlled station, and particularly of the receiver subsystem, are being investigated by other government agencies, DEI officials said. ■



Second Aerojet 260-in. Case Passes Hydrotest

AEROJET-GENERAL'S second 260-in. maraging steel solid motor case survived hydrotest Aug. 14 at Sun Shipbuilding & Dry Dock Co., Chester, Pa. The 60-ft.-long vessel was loaded with 160,000 gals. of water and pressurized to internal pressure of 737 psi. Level was maintained for two minutes before water was released. First case, hydrotested March 10, is awaiting firing at Aerojet's Dade (Fla.) Div.

Opportunities In

STRUCTURAL ANALYSIS

General Dynamics/Convair has immediate openings for Structural Analysis in San Diego, California.

Specialists are required to perform structural analysis on advanced missile and space vehicle designs and associated ground equipment. Additional tasks in this area are the development of new analysis methods and the testing of vehicles and components for evaluation of structural adequacy.

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Manned Venus Flyby Possible in '75

Outlook for Venus and Mars trips highlights conference co-sponsored by VPI, Langley and AFCRL; 'swing-by' mode strongly urged

by William S. Beller

BLACKSBURG, VA.—A three-man flyby of Venus could be accomplished in 1975, and a similar flight past Mars in 1979. A landing on Mars could be achieved in 1980-82 if all went well on the flybys.

This is the timetable worked out by NASA Marshall Space Flight Center scientists and described by Dr. Harry O. Ruppee, chief of missions and vehicle analyses, during the conference on "The Exploration of Mars and Venus," jointly sponsored here Aug. 23-27 by Virginia Polytechnic Institute (VPI), NASA's Langley Research Center and the Air Force Cambridge Research Laboratories.

The Mars flight "in all probability" would follow a swing-by trajectory (see below) around Venus on its return leg. This would conserve fuel and weight by flattening the re-entry angle, thereby lowering the speed of the spacecraft into the Earth's orbit.

For these flights, Ruppee envisions using chemical launch vehicles and *Apollo* technology. For the Venus flyby, 600,000 lbs. would first have to be lifted into Earth orbit; for the Mars flyby, 1 million lbs. would be required. Since the *Saturn V* can carry only 300,000 lbs. into Earth orbit, four launches would be needed to get the 1 million lbs. into orbit, after losses are considered. The first *Saturn V* launch would carry crew and spacecraft and the succeeding three launches would carry the fuel. Launch out of Earth orbit to planetary orbit would be by a "brand new" *Saturn* S-II stage, according to Ruppee.

Observing that "NASA has not yet planned a manned interplanetary project," he said a decision would be needed by 1968 for a 1975 manned Venus flyby. This is in line with the usual seven years lead time needed for large projects.

● **MEM plan**—The first Mars landing probably would call for a crew of eight to nine men aboard the mother spacecraft, three of whom would go to the planet's surface by means of a Mars excursion module (MEM), according to Ruppee. Two MEM's would be carried, one of them as "a spare tire" which would be sent to the Mars surface first and used if the second MEM, carrying the three astronauts, were damaged in landing. The landers would weigh 80,000 to 100,000 lbs.

The Mars spacecraft is expected to run its instruments and equipment by nuclear power—a radioisotope thermal-electric generator. Ruppee said four of these new machines would be strung together to generate a total of eight electrical kilowatts. He expects there would be TV scanning of Mars with "one relatively low-quality picture a second" being transmitted to Earth. The quality would be comparable to those pictures transmitted by *Mariner IV*. In addition, there would be film coverage for subsequent transmission.

The astronauts in the Mars spacecraft might have a centrifuge on board in order to get 1 to 1.5-g exercises during weightless flights. In addition, they would have a "storm cellar" aboard to protect them from solar flares. Even though "the solar hazard grows less as we gain solar-flare knowledge," the "cellar" would be shielded with 15 grams per square cm. of material as against 2 g/cm^2 in the cabin, said Ruppee.

He said that during the manned Mars flyby mission, which would take about five hours of "direct encounter with the planet," about 10,000 lbs. of equipment would be released from the spacecraft. This might include small orbiters, probes, and impact instrumention.

● **Snow on Venus?**—The fact that the temperature on the illuminated side of Venus is about the same as that on its dark side may be explained by water vapor condensing to snow as it passes from the bright to the dark area.

This theory was advanced at the meeting by John Strong, Johns Hopkins University scientist and balloon astronomy specialist.

Strong admitted his interpretation may be "Gulliverian," but said no other theories have been suggested to explain temperature evenness.

He said snow would have to fall at a rate of about 40 grams per square centimeter on the dark side to maintain the 234-6 degrees Kelvin temperature characterizing the upper-layer clouds on both sides. Heat would be released as the water vapor condensed.

Strong hypothesized that winds averaging 120 mph and carrying some 0.9 grams of vapor per square centimeter would have to sweep over the "twilight" zone to deposit the amount of snow required for the heat balance. Later this year, he said, a Johns Hopkins balloon with a telescope will be sent up to "explore" the Venusian atmosphere and perhaps verify the snowfield theory.

Johns Hopkins' work in balloon astronomy led to the discovery, in 1959, of water vapor in the planet's atmosphere.

● **Swing-by dividends**—A flight from Earth to Mars can be made with a 30% saving of fuel, in comparison with a conventioinal trajectory, by utilizing a swing around Venus. Up to 60% savings might be possible through use of similar modes in flights to the outer planets.

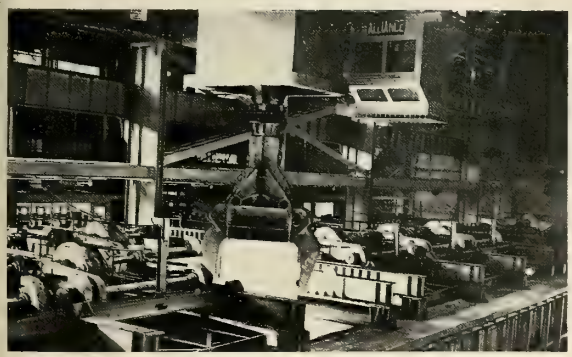
Victor G. Szebehely, Yale Observatory astronomer, said it would be "silly and wasteful" to use anything other than a swing-by on a manned flight to Mars.

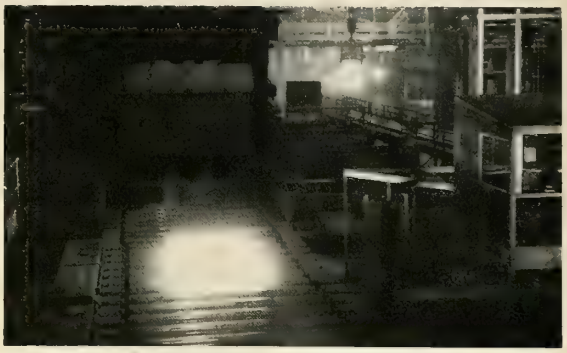
Using the gravitational field of one planet to alter the trajectory of a passing spacecraft and direct it toward a second planet has been proposed by staffers at Ames Research Center, Jet Propulsion Laboratory and NASA headquarters. Szebehely says most of the credit should go to an Ames researcher. His own contribution has been development of a technique for calculating precise trajectories for spacecraft flying very near a planetary body.

The round trip to Mars, with a pivot around Venus, would take 540 days, including 10 days of dwelling time, Szebehely said. A similar trip via standard orbit could be accomplished 110 days sooner but would require 30% more fuel. ■

How Lukens Turned Out Titan Plates

Careful monitoring and coordination enabled firm to produce units for Titan III-C motor case program with existing equipment





LEFT: Crane plucks D6AC ingot from soaking pit prior to rolling. RIGHT: Roll openings were controlled to increments of 0.01 in. Widest finished plate measured 160 in.; longest reached 492 in.

THE D6AC PLATES used to fabricate the 120-in. rocket motor case for the Air Force *Titan III-C* launch vehicle were rolled and finished on standard equipment at Lukens Steel Co.—yet met the exacting specifications for the development program.

Most steelmaking facilities in the U.S. are not geared to handle aerospace alloys efficiently using standard production methods. It is also economically impractical to install new equipment to process the small amount of steel used.

In addition, the low production quantities characteristic of missile and space requirements force steel fabricators into unique areas of process and production management techniques.

For instance, even though the *Titan III-C* has made its maiden flight and 11 more flights are planned over the next 20 months, suppliers far back in the pipeline reach the end of their contract commitments early.

Lukens has completed its portion of the *Titan III-C* effort—which consisted of converting vacuum arc-remelted D6AC ingots into finished plates.

● **Special task force**—The firm's production experts were convinced at the outset of the program that existing equipment could produce the necessary results if each steelmaking operation was monitored carefully.

A task force was formed and divorced from all other normal mill functions. This team of production specialists controlled operations on existing machinery and performed check-up tests at each production stage. Every department within Lukens participating in any way in the processing of the D6AC plates assigned a man to be completely responsible for that phase of the operation.

A production specialist was delegated to coordinate all D6AC activities until the order was completed. "Operation White Glove," as it was called, resulted in the on-time delivery and 100% acceptance of every plate. ■

LEFT: Vidigage checks assured thickness variation. Gauge tolerances were held to plus 0.038 in. and minus 0.010 in. RIGHT: Finished plate emerges from vertical blasting machine ready for shipment to case fabricators.

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Systems Analysis Concept Snowballs

The systems engineering approach to program planning for business and government agencies is being supported by a new Michigan firm, Technology Planning Center, Inc., Ann Arbor. Joining with efforts of four California firms in applying experience and knowledge gained from work in defense and space programs to other problem areas (M/R, Feb. 15, p. 24), the company uses a technique it calls "multidisciplinary systemodel analysis" for more effective long-range planning. Founded by Robert R. Kley and James C. Kellogg, both former defense and space system analysts, the firm aims to raise profits for corporate clients and help government agencies better serve the public. Less than one year old, it is already applying these planning concepts to projects under two contracts—one for the Air Force Office of Scientific Research and one for an agency of the state of Michigan. The company uses systems experience combined with modern analytical methods, information theory and mathematical simulation to help clients "see over the horizon." An example is a Michigan firm serving the transportation industry that is attempting to determine how it can fit into the projected $75-billion-a-year market of 1975. According to Kley, use of the MSA technique will help a firm maintain a market orientation for product projections by determining more precisely what future needs will be. The system can also help government agencies pinpoint and prepare to meet emerging social needs. This enables a government executive to conserve tax revenues by avoiding false starts, and serves the public better by fulfilling unmet social needs. Kley listed several areas in which he feels the systems approach can be effectively applied. These include health systems, natural resources development and management and outdoor recreation program and facility planning.

Mergers and Acquisitions

Winsco Instruments & Controls Co., Inc., Santa Monica, Calif., has acquired the assets of Electro-Oceanics, Inc., Encinitas, Calif. Winsco manufactures temperature-measurement and control instrumentation. Electro-Oceanics will be operated as a division of Winsco.

Facility Expansions

A mixing facility, increasing the production capacity of solid-propellant rocket motors, has gone "on-stream" at Lockheed Propulsion Co.'s Potrero Production and Test Facility at Redlands, Calif. The slurry mix station is used in preparation of 300-gallon batches of rocket propellant. It is capable of mixing one fuel batch per hour and is used in conjection with Lockheed's 300-gallon vertical planetary mixer. . . . *Taylor Corp., Valley Forge, Pa., has announced a $2-million expansion and modernization program, increasing the facility to approximately 350,000 sq. ft. Completion is scheduled for 1967. The firm manufactures laminated plastics and vulcanized fiber.* . . . Northrop Space Laboratories plans to build a 20,000-sq.-ft. addition to its installation at Huntsville, Ala. The expansion will include laboratory facilities and will bring the total area up to 48,000 sq. ft. . . . *CTS Corp. has relocated its subsidiary, CTS Microelectronics, Inc., from Ridgefield, Conn., to West Lafayette, Ind. A 45,000-sq.-ft. addition is nearing completion at the CTS Research, Inc., facility there.*

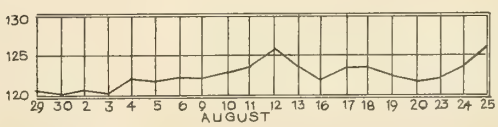
International

Bissett-Berman Corp., Santa Monica, Calif., and Plessey Co. Ltd., Ilford, Essex, England, have reached an agreement for exchange distribution and manufacturing cross-licensing of their products in the meteorological and oceanographic fields. Plessey will market the Bissett-Berman "Hytech" line of equipment in the British Commonwealth, Holland, South Africa, Norway and Sweden. Bissett will become exclusive distributor for Plessey products in the U.S. . . . *Siemens-Schuckertwerke AG has inaugurated its new 656,000-sq.-ft. Research Center in Erlangen, Germany. Said to be Europe's largest private enterprise research establishment, the center will be used to study the fields of semiconductors, superconductors, plasma physics, energy conversion, automation, control engineering and reactor development.* . . . Avnet Shaw, Plainview, N.Y., has announced that F. W. Berk & Co., Ltd., U.K. licensor for the Shaw Process, has installed an experimental Shaw foundry at its R&D division in Harlow, England.

Missile/Space Stock Index

The Missile/Space Weighted Stock Index shot to its highest mark Aug. 25 with the announcement by President Johnson that the United States would go ahead with development of another major space program, the Air Force *Manned Orbiting Laboratory*. The index hit 126.03 by the close of business that day.

The Index has remained above 120 for the entire month of August. It has been stimulated by the Secretary of Defense's request for an additional $1.7 billion to be added to the budget to cover the needs of fighting in Viet Nam until a supplemental request for additional funds can be made in January. The 19 companies in the Index meet the requirements of doing more than $200 million in sales each year, more than half of which is in the defense/space field, and being listed on the New York Stock Exchange.



100 = CLOSING PRICES OF 19 REPRESENTATIVE AEROSPACE FIRMS DEC. 31, 1964
STOCK PRICES FURNISHED BY MERRILL LYNCH, PIERCE, FENNER AND SMITH

contracts

AIR FORCE

$1,494,000—**General Electric Co.,** Philadelphia, to test re-entry vehicles.

$1,383,480—**Weinschel Engineering,** Gaithersburg, Md., for procurement of newly developed insertion-loss measuring equipment.

$1,000,000—**General Dynamics Corp.,** Convair Div., San Diego, to make *Atlas-Agena* boosters.

$976,000—**Radio Corp. of America,** Missile & Surface Radar Div., Moorestown, N.J., for spare parts and services for radar equipment.

$758,000—**Radio Corp. of America,** Aerospace Systems Div., Burlington, Mass., for AN/TSQ-47 updating.

$599,000—**Radio Corp. of America,** Missile & Surface Radar Div., Moorestown, N.J., for radar equipment.

$500,000—**Motorola, Inc.,** Military Electronics Div., Scottsdale, Ariz., for procurement, fabrication, testing and delivery of a number of C-band instrumentation transponders.

$181,275—**Crucible Steel Co. of America,** Pittsburgh, for process development program of high-strength, formable beta titanium alloy.

$171,802—**North American Aviation, Inc.,** Rocketdyne Div., Canoga Park, Calif., for research of high-energy oxidizers.

$125,000—**Thiokol Chemical Corp.,** Wasatch Div., Brigham City, Utah, to study the possibility of using *Minuteman* first stage (M-55) rocket motors as strap-on boosters to augment the thrust of non-manrated versions of the Titan *III-X* space launch vehicle.

$114,870—**Princeton University,** Princeton, N.J., for a study of combustion processes in liquid propellant rocket motors.

$101,712—**Ethyl Corp.,** Baton Rouge, La., for synthesis of solid propellants.

$88,121—**STD Research Corp.,** Pasadena, Calif., for research on collision cross sections for momentum transfer in plasmas.

$25,000—**Ohio State University Research Foundation,** Columbus, for transmission of intense laser radiation.

ARMY

$7,500,000—**Whittaker Corp.,** Telecomputing Services, Inc., Los Angeles, for data-reduction services at White Sands Missile Range, N.M.

$5,435,600—**Raytheon Co.,** Andover, Mass., for reconditioning of assemblies of the *Hawk* missile system.

$2,000,000—**The Boeing Co.,** Seattle, to continue research and development on the *HIBEX* anti-missile missile propellant.

$1,600,000—**Raytheon Co.,** Redstone Arsenal, Ala., for research and development of a self-propelled *Hawk* missile system.

$1,244,800—**Philco Corp.,** Aeronutronic Div., Newport Beach, Calif., for industrial engineering services for the *Shillelagh* missile system.

$1,200,000—**Raytheon Co.,** Andover, Mass., for items for ground support equipment for the *Hawk* missile system.

$1,140,000—**Babcock Electronics Corp.,** Babcock Aerospace Div., Costa Mesa, Calif., for procurement of remote control systems and radio receiver-decoder units used on aircraft-type missile target vehicles.

$1,000,000—**Hercules Powder Co.,** Wilmington, Del., for maintenance and support services.

$717,000—**Bulova Watch Co.,** Jackson Heights, N.Y., for rocket fuzes.

$499,403—**Aerojet-General Corp.,** Huntsville, Ala., for continued development of a polybutadiene composite propellant for the *Sprint* anti-missile missile.

$375,000—**Lear Siegler, Inc.,** Electronic Instrumentation Div., Anaheim, Calif., to provide a high-speed telemetry data-handling system.

$250,000—**Molecular Research, Inc.,** West Palm Beach, Fla., for fabrication and installation of operational intercommunications and TV systems for NASA's Merritt Island Launch Area.

$90,299—**Braddock, Dunn and McDonald,** El Paso, Tex., for theoretical studies of *Nike-X* missile system.

$50,000—**Philco Corp.,** Western Development Laboratories Div., Palo Alto, Calif., for Phase II of a feasibility study of a transportable satellite communications terminal to meet future military requirements.

$48,372—**Raytheon Co.,** Andover, Mass., for repair parts for *Hawk* missile.

$34,758—**American Optical Co.,** Space Defense Div., Pittsburgh, for parts and components for contraves cinetheodolites.

NAVY

$6,500,000—**Radio Corp. of America.,** Communications Systems Div., Camden, N.J., for a classified program.

$4,252,764—**Avco Corp.,** Richmond, Ind., for *Polaris* arming and fuzing devices.

$2,366,397—**North American Aviation, Inc.,** Rocketdyne Div., McGregor, Tex., for Mk 36 Mod 2 rocket motors.

$1,753,000—**North American Aviation, Inc.,** Autonetics Div., Anaheim, Calif., for FY 1966 SINS repair program.

$1,601,750—**Sperry Rand Corp.,** Sperry Gyroscope Div., Syosset, N.Y., to fabricate, test and furnish SINS module test sets, including external standard test equipment.

$1,346,625—**Canadian Commercial Corp.,** Canadian Industries Ltd., Washington, D.C., for rocket motor propellant.

$430,000—**Ampex Corp.,** Redwood City, Calif., to develop two new instrumentation tape recorders.

$166,672—**Defense Electronics, Inc.,** Rockville, Md., for a telemetry data-reduction station to process data for the drone anti-submarine helicopter (DASH) evaluation program.

$117,875—**Filters Inc.,** Engineered Fabricators Inc., San Jose, Calif., for glass fiber spacers for 2.75 in. rocket motors.

NASA

$2,000,000—**Radio Corp. of America,** Aerospace Systems Div., Van Nuys, Calif., increase for the *Saturn* computer program.

$2,000,000—**American Science & Engineering, Inc.,** Cambridge, Mass., for design, development, test and delivery of an X-ray astronomy experiment and supporting data system for the second *Apollo* manned mission.

$903,000—**Lear Siegler, Inc.,** Electronic Instrumentation Div., Anaheim, Calif., for design and installation of electronic instrumentation and control equipment previously delivered to Marshall Space Flight Center.

$870,000—**Philco Corp.,** Houston Operations, Houston, for a display converter for an all-electronic television display system with color capability.

$373,834—**North American Aviation, Inc.,** Los Angeles Div., Los Angeles, for development of a titanium S-1C skin section.

$289,996—**Systron Donner Corp.,** Concord, Calif., for linear accelerometer systems.

$256,436—**University of Texas,** Southwestern Medical School, Dallas, for design, development, fabrication and test of flight hardware.

$240,000—**Radio Corp. of America,** Astro-Electronics Div., Princeton, N.J., for a TV scan converter.

$236,870—**Hughes Aircraft Co.,** Culver City, Calif., for a continuous wave laser study.

$236,000—**Radio Corp. of America,** Astro-Electronics Div., Princeton, N.J., for the *Tiros* program.

$196,890—**Graduate Research Center of the Southwest,** Dallas, for a feasibility study for using a coincidence mass spectrometer to measure lunar atmosphere constituents.

$148,553—**United Aircraft Corp.,** Research Laboratories, East Hartford, Conn., for an investigation of non-equilibrium flow effects in hydrogen-fluorine rocket nozzles.

$148,357—**D. Brown Associates Inc.,** Eau Gallie, Fla., to study computational system requirements for the flight dynamics function for Project *Apollo* instrumentation ships.

$116,900—**Electro-Optical Systems Inc.,** Pasadena, Calif., for a micrometeoroid sampling instrument.

$99,970—**Melpar, Inc.,** Falls Church, Va., to design and develop gas volume meters.

$92,414—**Microwave Associates,** Burlington, Mass., for an RF converter system.

$78,500—**Philco Corp.,** Communications and Electronics Div., Willow Grove, Pa., for development of a color television monitor for the all-electronic TV display system.

$76,181—**TRW, Inc.,** TRW Systems Group, Redondo Beach, Calif., for a study of unidirectional thermal radiation properties of materials.

$58,586—**United Aircraft Corp.,** Hamilton Standard Div., Windsor Locks, Conn., for man-system task analysis for lunar surface experiments.

INDUSTRY

$1,376,200—**The Bendix Corp.,** Eclipse-Pioneer Div., Teterboro, N.J., from **Grumman Aircraft Engineering Corp.,** Bethpage, N.Y., for LEM range indicators.

$575,000—**Pennsalt Chemicals Corp.,** Stokes Advanced Systems Dept., Philadelphia, from **General Motors Corp.,** AC Electronics Div., Milwaukee, to design, furnish and install a new space simulation facility.

$295,000—**Radio Corp. of America.,** Camden, N.J., from **McDonnell Aircraft Corp.,** St. Louis, for a radio receiving set.

$279,000—**Lear Siegler, Inc.,** Santa Monica, Calif., from **General Electric Co.,** Mississippi Test Support Operations, Bay St. Louis, Miss., for *Saturn* S-II stage test instrumentation and controls.

$195,000—**Lear Siegler, Inc.,** Electronic Instrumentation Div., Anaheim, Calif., from **The Boeing Co.,** Seattle, for television cameras and associated equipment for use on flight stages of the *Saturn V* rocket.

$110,000—**Conic Corp.,** San Diego, from **The Boeing Co.,** Seattle, to supply transmitters as part of an in-flight monitoring system for the five engines of the *Saturn V* first-stage rocket.

ARPA

$16,200,000—**General Telephone & Electronics Corp.,** Sylvania Electric Products Inc., New York City, to design, build and install an experimental long-range tracking and instrumentation radar system that will aid anti-missile studies.

$550,000—**Avco Corp.,** Research and Advanced Development Div., Wilmington, Mass., to study advanced penetration aids systems.

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Are you contemplating a military export program? ☐ **Yes** ☐ **No.**

New Product of the Week: Cryogenic Circulator

A cryogenic stripline circulator, designed for operation at temperatures down to —269°, is being marketed by The Marconi Co.

The unit was developed for use in certain types of low-temperature, low-noise amplifiers used in satellite communications receiving systems. The circulator employs a ferrite material which has properties at the temperature of liquid helium similar to those of a normal ferrite at room temperature. The four-port device operates in a frequency range of 3,600 to 4,300 mc. Insertion loss is 0.3 db for ports 1 to 2 and 3 to 4, and 0.6 db for ports 2 to 3 and 4 to 1. VSWR is 1.25 at 4.2°K and 1.15 at 77°K and 20°C.

Circle No. 151 on Subscriber Service Card

Catalyst Carrier

Norton Co.'s refractories division has available a new catalyst carrier, the Macroport 05 fused alumina carrier. Average pore sizes for the carrier are 1,000 to 1,500 microns in diameter. This compares with 20 to 180 microns for standard Macroport carriers.

There is far less restriction to the access of reactants and release of products with the carrier. It is said to provide excellent abrasion resistance. The carriers are available as spheres in 3/16 in. x 3/16 in. and 1/4 in. x 1/4 in. sizes and as aggregate.

Circle No. 152 on Subscriber Service Card

Precision 'Avometer'

A precision 'avometer,' capable of making ac/dc voltage and current measurements with a high order of accuracy, is available from Amacoil Instruments. The device combines 34 ranges into a single multi-purpose meter, eliminating the need for several different measuring instruments.

Accuracy of the precision avometer is ±0.3% of FSD on d-c voltage; ±0.5% of FSD on d-c current; and ±0.75% of full scale deflection on a-c voltage and current ranges. Sensitivity is 100 ohms per volt. Voltage ranges extend from 1.5v to 1,500v, and current ranges from 1.5 milliamps to 15 amps. Built-in interlocking switches protect the instrument from accidental damage.

Circle No. 153 on Subscriber Service Card

Supermendur C-Cores

The Arnold Engineering Co. has available a line of C-cores made of Supermendur, an alloy of 2% vanadium, 49% iron and 49% cobalt, which permits practical savings in volume from 15 to 40% and weight from 10 to 30%, and with performance capability comparable to C-cores 1/3 larger in size.

The cores are made of 4-mil Supermendur and range in weight from 0.04 lbs. up to 3.93 lbs.; strip widths from 3/8 in. through 1 3/4 in.; build up from 3/16 in. to 1 3/16 in.; window widths from 1/4 in. to 1 3/8 in.; window lengths from 5/8 in. to 3 in.

Circle No. 154 on Subscriber Service Card

Latching Relay

Filtors, Inc., has introduced a four-pole double-throw latching relay with 0.2 grid-spaced terminals. The DJL subminiature crystal case relay has a four Form C latching configuration. A special feature is the unique design of a four-pole motor with a single H-shaped armature, which provides a higher degree of confidence than double-armature configurations.

The contact rating is 2 amperes, resistive, with a vibration rating of 30 g's maximum from 5 to 2,000 cps; 20 g's to 3,000 cps. It has a 100-g shock rating at 11 μsec. duration. Latch and reset time is 4 μsec. maximum.

Circle No. 155 on Subscriber Service Card

Telemetry Deviation Meter

An S-band telemetry FM deviation meter has been developed by Advanced Measurement Instruments, Inc. It is designed to measure the peak deviations of frequency modulated signals with an accuracy of ±2%.

only a beginning...

MISSILES AND ROCKETS will publish its Fifth Annual NASA Issue November 29, 1965. This issue, now accepted as the authoritative annual publication on the nation's space agency, will examine the National Aeronautics and Space Administration's current and future projects and facilities.

After a year of spectacular achievement, including Astronaut White's record extravehicular space walk, NASA is looking ahead to its new space programs. Special emphasis is placed in this issue on the earth orbit, lunar orbit and lunar landing missions, which have an estimated total cost of over $1 billion and project Voyager, which will explore Mars, Venus and other planets.

This special issue will also explore NASA's plans for other projects as the U.S. space program begins its swing away from the exploration of the Moon to the vaster and more challenging mission of probing the planets..

MISSILES AND ROCKETS provides the recognized and authoritative route to reach the men who will be making the research, design, engineering and procurement decisions in these new multibillion-dollar programs.

BONUS CIRCULATION

By request, the Fifth Annual NASA Issue of MISSILES AND ROCKETS will provide 5,000 bonus circulation to the decision-makers in NASA, AEC and ComSat Corp. This means more impact, more readership for your advertising dollars in MISSILES AND ROCKETS.

Publication Date: November 29, 1965 **Closing Date: November 15, 1965**

MISSILES AND ROCKETS, 1001 Vermont Avenue, N.W., Washington, D.C. 20005

Designated the Ami Model 400S, the instrument enables carrier frequency range to be read directly within ±0.5% from 2,100 to 2,400 mc, and indicates peak deviation directly to 6,000 kc. The deviation meter is a broadband FM receiver with an ultra-linear discriminator and an accurate readout. Deviation is indicated by a linear voltmeter and is accurate to ±2% FSD up to 1,000 kc. Four peak deviation ranges are provided, with a resolution of 1 kc in the 100 kc range. The de-modulation distortion is less than 0.2% up to 500 kc allowing the measurement of deviation with a high degree of accuracy. Carrier shift is indicated directly to ±1.0 mc with an accuracy of ±5%.

A unique feature is the stable internal calibration signal that allows the operator to re-calibrate the deviation with a high degree of accuracy. Applications of the meter extend from monitoring FM transmitters to measurement of telemetry signals by providing a demodulated output that can be analyzed for distortion, hum and spurious responses.

Circle No. 156 on Subscriber Service Card

Signal Conditioning Unit

Rosemount Engineering Co. has a signal conditioning amplifier which provides a linear 0 to 5-v output from resistance temperature sensors.

The amplifier can be supplied as an integral part of the temperature sensor or as a separate package. The complete unit can operate over the temperature range of −320° to +250°F. The measurable temperature range is −430° to +1,800°F.

The amplifier further features a 0 to 5-v output for spans of 50°F or more; ±0.1% linearity; ±0.1% repeatablity; 28 ±4-v input; 100 meg input-output isolation and built in calibration circuit.

Circle No. 157 on Subscriber Service Card

Liquid Level Gauge

An entirely new method of measuring the level of liquids in containers has been announced by Barton Instrument Corp., a subsidiary of International Telephone and Telegraph Corp.

The Model 293 pressure-balance system eliminates the necessity, in most installations, of mounting a meter at or near the bottom of a vessel in which liquid is to be gauged, and makes it possible to obtain accurate and reliable measurement control at remote locations up to several hundred feet away from the vessel.

It operates by sensing the effect of the weight of the liquid on the air pressure in a sealed immersed sensor; a remote measurement of the air pressure gives a direct indication of the amount of liquid above the sensor, and hence of the height of the liquid in the container.

No gas or liquid is introduced into the process medium to provide the possibility of dilution or contamination. There are no open tubes which may become clogged with solid material or organic growths, and corrosive or toxic fluids are prevented from entering the area where the meter is installed by way of the piping connections. Sensors are available for three different types of installations: full immersion in tank, pipe connection to tank, and flange connection.

Circle No. 158 on Subscriber Service Card

Piston Actuator

A microminature piston actuator for one-shot missile/space applications has been developed by Aerospace Components Div. of Atlas Chemical Industries, Inc.

The Model 1MI157 offers a power-to-weight ratio of 40,000:1, compared to a 5.9:1 ratio for a typical solenoid. The device is sealed to prevent gas leakage before, during and after firing. Power requirement is 2 watts for 10 millisecs.; current then may be removed and the piston will remain extended.

Circle No. 159 on Subscriber Service Card

Attenuator

Somerset Radiation Laboratory, Inc., has developed the Model X430 switch/modulator/voltage-controlled attenuator. This device features low bias current, improved bias-circuit impedance and choice of either polarity grounded biasing or straight-through bias drive in an ungrounded system. It internally connects switching diodes in series, rather than in the usual parallel connection.

Minimum attenuation of 3.0 db or less is realized from 8.5 to 9.5 gc with a total diode current of 150 ma, which is one-third the current formerly required for a three-diode switch. Isolation is greater than 60.0 db.

Either polarity can be selected by attaching the shorting cap to either of the two BNC connectors. For feed-through ungrounded operation, the shorting cap is removed entirely, allowing the maximum flexibility in bias-circuit design. Both ends of the series diode string are bypassed to ground at X-band frequencies.

Circle No. 160 on Subscriber Service Card

Four-Digit Voltmeter

Trymetrics Corp. has developed a series of four-digit digital voltmeters designed for accuracy, flexibility and economy. The series consists of four

basic units with 11 different plug-in function heads. The basic units each provide an accuracy of 0.05% of reading ±1 count.

The Series 4000 DVM basic unit furnishes full four-digit resolution with the accuracy of reading maintained over a 50°C temperature range by a simple front panel adjustment. Three different types of printout capabilities are available to drive mechanical printers.

Packaged to fit a standard 19-in. relay rack for systems applications with a panel height of 5¼ in., the voltmeter also has a variety of compatible plug-in heads providing d-c voltage measurements from 0.1v to 1,000v full scale. These heads are available in single or multiple range models with manual or automatic ranging capabilities.

Circle No. 161 on Subscriber Service Card

Programming Switches

A series of microminiature programming switches that can handle any number of events distributed over any time interval from milliseconds to minutes has been developed by Aerospace Component Div. of Atlas Chemical Industries, Inc.

The MMPS series of one-shot switches is hermetically sealed and offers firing intervals as short as 50 milliseconds or as long as 60 seconds or more. Programming is accomplished by controlling the burning rate of powder packed in a delay column. Powder may

be of a constant burning rate or graded into zones of different burning rates to provide longer or shorter timing intervals.

Switches are single-pole, normally open or normally closed and capable of handling 2 amps. The switch can be used to fire an additional switch with up to eight poles and a capacity of 10 amps.

Circle No. 162 on Subscriber Service Card

Frequency Changer

A solid-state frequency changer for heavy duty use has been developed by Microdot Magnetics, Inc. The 3.2-kva unit supplies power for operations requiring 400 cps high voltage.

The device supplies three-phase 0 to 3.2-kva continuous output at 400 ± 1 cycle from a three-phase, 60 cps, 208v input. Harmonic distortion does not exceed 5%. Efficiency is rated at 75% full load, 51% at 10% full load. Operating temperature range is 0 to 55°C.

Circle No. 163 on Subscriber Service Card

Glass Capacitors

Two lines of glass-dielectric electronic capacitors—one for military and one for industrial application—are being marketed by Westinghouse Electric Corp.'s Electronic Capacitor Dept.

The Type CY military units cover capacitance range of 0.5 through 300 pF with voltage ratings of 300 and 500v at 125°C. The Type CW industrial capacitors cover the range of 0.5 through 1,200 pF with voltage ratings of 100 and 500v at 125°C.

Both types meet MIL-C-11272 specifications. Electrical characteristics provide 2,000 hours of operation at 150% rated volts and 125°C with a capacitance change of no more than 0.5%.

Circle No. 164 on Subscriber Service Card

Micro Comparator

A micro-comparator and electronic displacement indicator is being marketed by Engis Equipment Co. The unit consists of an inductance-type measuring head connected electrically to an indicator unit. Two measuring heads are available, side acting and axial, together with a range of styli.

The unit accommodates five measurement ranges on two scale lines with magnifications from 160x to 16,000x. Accuracy is 2% or better over full scale.

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Dr. Larry C. Hunter: Appointed director of the Electronic Defense Laboratories of Sylvania Electronic Systems, division of Sylvania Electric Products Inc. He was formerly manager of the Systems Laboratories at EDL.

Lynn G. Walck: Elected a vice president of Baldwin-Lima-Hamilton Corp. Coming from Fairchild Hiller Corp., he joined BLH in 1957 as corporate director of industrial relations.

Stanley B. O'Kane: Elected vice president and treasurer of Leach Corp. He is responsible for all corporate financial, accounting and contract administration functions. He is also an officer and treasurer of Leach International S.A., a subsidiary.

Donald G. Nyberg: Joined Rocket Research Corp. as manager of propellant technology. He was formerly head of the liquid propellant engines section in the Propellant Dept. of the U.S. Naval Ordnance Test Station, China Lake, Calif.

Barrett L. Taft: Appointed manager of materials engineering at the Orlando Division of Martin Co. He will manage work in the development and fabrication of advanced aerospace materials.

J. Edmund Fitzgerald: To manage the newly organized Development Branch at Lockheed Propulsion Co. **John H. Bonin** will head the new Research Branch. Both new branches were formed from the Research and Engineering Branch.

Dr. Jose Giner: Joined the staff of Tyco Laboratories, Inc., as a senior scientist. His primary field of interest is research in fuel cells.

Paul Marecek: Joined The Singer Co., Metrics Div., as chief mechanical engineer. He was formerly with Polorad Electronic Instruments.

Riccardo Vanzetti: Appointed manager of infrared techniques and systems in the advanced development laboratory for Raytheon Company's Wayland Lab.

W. Richard Purcell, Jr.: Joined the staff of the Columbus Laboratories of Battelle Memorial Institute as a diversification economist specializing in the electronics, aerospace and capital equipment industries.

Dr. Antonio Ferri and J. D. Wethe: Elected to the board of Marquardt Corp. Dr. Ferri has jurisdiction over the newly established science and technology group, which includes General Applied Science Laboratories Inc., a recently acquired subsidiary. Wethe heads the product operations group, the largest of Marquardt's divisions. **Russell S. Wilshusen** and **Peter Speliotis** were elected vice presidents.

Donald M. Spinell: Appointed director of technical information for the Industrial Fasteners Institute.

Charles B. Thompson: Promoted to manager of the Electronic Systems Div. of Brown Engineering Co. Also promoted were **David A. Moseley** to deputy division manager for contracts, and **James R. Wright** to head of the newly-established dicrete control equipment program management department.

Lyman S. White: Named manager of Beech Aircraft Corp.'s Houston region. He will be responsible for coordinating all Beechcraft programs with the NASA Manned Spacecraft Center.

Geoffrey F. Meakes: Appointed chief engineer of Racal Communications, Inc.

Roland A. Tripp: Named manager of the *Short Range Attack Missile (SRAM)* program at Thiokol Chemical Corp.'s Wasatch Div. He will have overall responsibility for program management activities in the division's bid to participate as propulsion contractor in the Air Force's new missile development and production program.

Dr. A. C. Makrides, Dr. Edward B. Roberts and Paul B. Rosenberg: Elected to the board of Tyco Laboratories, Inc. Makrides is vice president and director of the Chemical Research Dept. at Tyco; Roberts is associate professor of industrial management at Massachusetts Institute of Technology; Rosenberg is treasurer and business manager at Tyco.

James A. Martenson: Promoted to the newly-created post of manager of market engineering at U.S. Polymeric, Inc.

C. Dudley Fitz: Became vice president of aerospace technology with the National Engineering Science Co. He was formerly chief of the penetration aids branch of the Advanced Research Projects Agency of the Department of Defense.

Arthur S. LaPine: Elected chairman of the board of LaPine Scientific Co. Also elected to company offices were **Robert J. LaPine,** president; **Theodore N. Slama,** executive vice president; **Harold A. Thuman,** vice president; and **Edward J. Power,** vice president.

Dr. Paul A. Hersch: Appointed manager of the research section of Gould-National Batteries, Inc. He will be responsible for basic and applied research in electrochemistry and other branches of chemical and physical science.

Livingston T. Merchant: Elected to the board of trustees of the Research Analysis Corp. He is executive director of the World Bank, former Under Secretary of State for Political Affairs, and former ambassador to Canada.

Dr. Joseph Antebi: Elected an associate member of Simpson Gumpertz & Heger Inc., consulting engineers. Also elected an associate member was **Arthur L. Brown, Jr.**

Albert H. Cohen: Named president of Danex Corp., a wholly owned subsidiary of Ferrodynamics Corp. He is also president of the parent corporation.

David R. Bradley: Elected to the board of directors of Electronic Communications, Inc. He is publisher of the St. Joseph, Mo., *News-Press and Gazette.*

David E. Stokes: Appointed manager of advertising and public relations for Pennsalt Chemicals Corp. He was previously assistant to the vice president of marketing.

Col. Harold J. Crumly, USAF (Ret.): Appointed to the long-range government planning group of The Bendix Corp.

Dr. Frank T. McClure: Awarded the John Scott Award for 1965 of the Philadelphia (Pa.) Directors of City Trusts. He is being presented the award this fall for his invention of the satellite doppler navigation system which is now being used to fix positions of naval ships at sea. He is chairman of the Research Center of the Johns Hopkins Applied Physics Laboratory.

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AUGUST

1965 International Symposium on Antennas and Propagation, sponsored by Institute of Electrical and Electronics Engineers (IEEE), Sheraton Park Hotel, Washington, D.C., Aug. 30- Sept. 1.

Twelfth National Conference of the Armed Forces Management Assn., Washington Hilton Hotel, Washington, D.C., Aug. 31-Sept. 2.

SEPTEMBER

Second Annual Conference on the Effects of Shock and Vibration on the Human Body, sponsored by University of Denver and the Colorado Chapter of the Institute of Environmental Sciences, University of Denver, Denver, Sept. 1-3.

URSI Symposium on Electromagnetic Wave Theory, sponsored by U.S. National Committee, International Scientific Radio Union (URSI), Technological University of Delft, The Netherlands, Sept. 6-11.

16th International Astronautical Congress, sponsored by the International Astronautical Federation, Athens, Greece, Sept. 12-18.

Thirteenth Annual Joint Engineering Management Conference, sponsored by American Institute of Aeronautics and Astronautics (AIAA), IEEE, American Society of Mechanical Engineers (ASME), and others, Roosevelt Hotel, New York City, Sept. 13-14.

Thermophysics Specialist Conference, sponsored by AIAA, U.S. Naval Postgraduate School, Monterey, Calif., Sept. 13-15.

Electrical Insulation Conference, sponsored by U.S. Navy Bureau of Ships and Allis-Chalmers Mfg. Co., New York Hilton, New York City, Sept. 13-16.

Symposium on Structural Adhesives Bonding, sponsored by Picatinny Arsenal (U.S. Army Munitions Command), Stevens Institute of Technology, Hoboken, N.J., Sept. 14-16.

Advanced Incentive Contracting, sponsored by National Defense Education Institute (NDEI), Washington, D.C., Sept. 15-17.

Astrodynamics Specialist Conference, sponsored by AIAA and Institute of Navigation, U.S. Naval Postgraduate School, Monterey, Calif., Sept. 16-17.

National Power Conference, sponsored by IEEE and ASME, Sheraton-Ten Eyck Hotel, Albany, N.Y., Sept. 19-22.

Fifth Annual National Conference on Environmental Effects on Aircraft and Propulsion Systems, sponsored by U.S. Naval Air Turbine Test Station, Nassau Inn, Princeton, N.J., Sept. 20-22.

Systems Engineering Exposition and Conference, McCormick Place, Chicago, Sept. 20-23.

International Conference on Thermionic Electrical Power Generation, sponsored by Institution of Electrical Engineers, London, Sept. 20-24.

Advanced Incentive Contracting, sponsored by NDEI, Los Angeles, Sept. 21-23.

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Finally

AWARD OF THE billion-dollar-plus *Manned Orbiting Laboratory (MOL)* program to Douglas Aircraft Co. means that the U.S. has at last embarked on a long-overdue manned military space program.

Announcement of the contract was made, naturally enough, at the White House. But the significance of the presidential setting goes beyond the mere political fact that one does not allow just anyone to pass out sums of such magnitude. The import is that the need for the program is understood and approved at the very highest level of the Administration.

This is a major asset in the future of *MOL*. Mr. Johnson is not one to let any project in which he has had a hand suffer from neglect. In addition, the President throughout his political career consistently has shown an understanding of the importance of space. As senator, vice president and president, he has played a primary role in creation of the political environment which has made it possible for the nation's scientists and engineers to keep the U.S. in a position of space leadership.

To date, this has been almost solely a civilian effort. We have been in the vulnerable position of setting out to explore and establish valuable channels of science and commerce without providing the means to protect them if necessary. In addition, we have left our establishments on the shores of the sea of space exposed to any new methods of attack which may develop there.

Nor is it only in the manned space field that we have neglected the vital importance of space to the military. A military communications satellite network should have been a reality long ago. Use of navigation satellites and weather satellites should now be commonplace in the military establishment. Only in the field of reconnaissance has there been a substantial operational program.

The very success of the *SAMOS* series of reconnaissance satellites was in fact one of the justifications for approval of *MOL*. A manned reconnaissance spacecraft offers the same order-of-magnitude improvement over *SAMOS* that a manned recce aircraft has over a photographic drone. The *SAMOS* photographs are startlingly good but a man has the advantage of being able to operate by exception—to pick out that which is moving, changing or significant.

At the very time *MOL* was receiving its official blessing, *Gemini* Astronauts Gordon Cooper and Charles Conrad were engaged in proving out the feasibility of just such reconnaissance. They successfully spotted and photographed two *Minuteman* launches from Vandenberg AFB, Calif., ground displays in the Southwest and rocket-sled exhaust from Holloman AFB, N.M.

The U.S. has come a long way in space since the dark days of *Sputnik I* and the Gagarin flight when it was little more than a spectator at an all-Russian show. The U.S. is now foremost in lunar exploration and planetary exploration. The duration of manned flight, while one yardstick, is not altogether a measure of how well the two countries compare in their manned space programs. The Soviets still have larger boosters and larger spacecraft, which make many accomplishments possible for them which still are beyond the reach of the U.S. program. The gap, however, is much smaller.

It is appropriate that as *Gemini* 5 whirled toward its significant accomplishment, *MOL* received its go-ahead. Our space spectrum now is much more complete.

IT IS EQUALLY APPROPRIATE that the *MOL* award should go to Douglas Aircraft. The company, in a preparatory move that was admittedly a gamble, had invested heavily of its own funds in the fine Huntington Beach Space Center. It has experience and a good record from its NASA projects. The Douglas background in study of *MOL* and related NASA efforts is unsurpassed.

And as for the goal of going around the world in the spacious cabin of a Douglas product, it is not exactly an unattainable one. The company for years has been building machines that do exactly that. They are called airplanes.

Indeed, news of the *MOL* contract cannot have been received at the Santa Monica headquarters without a certain twinge of regret. For it means that for the first time since the founding of the company, we are looking ahead to two new generations of commercial aircraft which will not have an entry carrying the Douglas name. Most assuredly, the awards for the C-5A aircraft and the Supersonic Transport are going elsewhere. In that sense, the *MOL* announcement is the end of a long trail for Douglas Aircraft.

But, in another, it is an open door to the future. Secretary McNamara himself has pointed out that the Department of Defense regards the *MOL* project as open-end, expecting it to lead to operational programs in a number of fields if the concepts to be tested prove out. There are many manned spaceflight areas other than visual reconnaissance where there are demonstrable military requirements and applications. Electronic reconnaissance is one. Satellite inspection and, if necessary, destruction, is another.

Although justly critical of Mr. McNamara for the long delay while reorienting the military space effort to *MOL*, the Air Force and industry in fact owe him a debt of gratitude for that re-orientation which swung military manned spaceflight away from the closed-end research approach of *Dyna-Soar* to the open-end operational promise of *MOL*. It will prove to be one of the major decisions of his term in office.

William J. Coughlin

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GUIDANCE AND CONTROL — B.S. in E.E. or Math with 3-5 years' experience. Assignments involve the ability to prescribe the requirements for advanced flight control and stability studies. Individuals will synthesize and analyze control systems for booster and space vehicles during ascent and in-orbit flight conditions.

STRUCTURAL AND MECHANICAL GROUND BASE DESIGN — Structural mechanical designers to work on missile ground transport and launch equipment. Experienced in fluid systems design, process piping, mechanical component design (valves, regulators, filters) or heating, ventilating, air conditioning equipment.

Layout and design of heavy steel support structure, slings, dollies, hoists, transporting, erection or handling equipment. Missile experience not mandatory. Engineering degree preferred.

STRUCTURAL DYNAMICS — Advanced degree with 5 years' senior technical experience. Performs highly complex aeroelastic, dynamic and/or load analysis or tests on an independent basis. Develop improved math models dynamic response analysis, buffet, gust and flutter.

PROPULSION — B.S. degree with 3-5 years' experience. Analysis, design and system integration of liquid and solid propellant systems. Assignments require thorough knowledge of thermodynamics, heat transfer and fluid dynamics. Experience applied to missile or space craft pressurization, propellant feed and rocket engine systems analysis. Must use existing IBM programs and set up new analytical approaches.

OPERATIONS ANALYSIS — Several senior and intermediate level positions requiring 3 to 8 years' proven aerospace experience with demonstrated modeling capability. Assignments will involve development of math models for various aspects of weapon and space systems effectiveness. Analyses will include study of existing and projected weapon and space systems via mission analysis, war-gaming, simulation, estimates of offensive and defensive force size and mixes, payload utilization and customer requirements. Applicants will have a Bachelors Degree and some advanced study.

INTELLIGENCE SPECIALIST — Will conduct critical analyses to establish intelligence parameters, effectiveness tradeoffs, determine impact on strategic offensive-defensive force requirements plus impact on future strategic weapon systems. A degree is important or 10 to 15 years' experience which is current in Stratintell, Data Acquisition, Processing, Sensor Command and Control Systems.

SPACE MISSION ANALYST — With B.S. and advanced work desirable plus 3 to 8 years' experience, will provide mission analyses of national space programs to develop trends for both launch vehicles and spacecrafts utilizing economic and technical knowledge will determine forcing functions and interactions between payload development and launch vehicle growth.

PARAMETRIC COST ANALYSIS — Economic aerospace background will be utilized to determine cost trends in large system development, procurement and operation. With historical data and technological projection, develop cost curves based on system parameters such as payload weight, pounds of vehicle, ballistic ranges, etc., that can be directly applied in cost effectiveness tradeoffs of future military and space systems. Bachelors Degree and 5 to 8 years' experience in cost analysis and economic planning.

COMPUTER PROGRAMMERS — To analyze, develop and implement business data processing applications for large scale tape oriented computer systems. IBM 7000 series experience desirable. Minimum two years' programming experience mandatory. B.A., B.S. or equivalent data processing experience required.

STRESS ANALYSIS — Utilizing computer techniques, will conduct stress analyses of airborne and ground structural and mechanical components involving large booster systems. Will plan and coordinate necessary testing. A B.S. degree and 3-5 years applicable experience is needed.

ACOUSTIC AND VIBRATION ANALYSTS — Graduate engineers, M.E. or E.E., with minimum of two years' experience on analysis and prediction of rocket and missile acoustic and vibration environments, to conduct post-flight studies on large booster systems.

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